Vol. 7 SEPTEMBER · 1944 No. 3

LLOYDIA

A Quarterly Journal of Biological Science

Published by the Lloyd Library and Museum, Cincinnati, Ohio

New and Interesting Cortinarii from North America

ALEXANDER H. SMITH

(*University of Michigan, Ann Arbor, Mich.*)

INTRODUCTION

Although species collected in various regions of North America are included in this report, by far the majority were found in the Olympic National Park on the Olympic Peninsula of the state of Washington. Most of the collections were made during the fall of 1941 while the writer was carrying on a survey of the agaric flora of western United States.[1] Most of the collections were made in the vicinity of Olympic Hot Springs, a station in the mountains a short distance south of Lake Crescent, but many interesting species were also found at Heart O'Hills on the slopes of Mt. Angeles. Both stations are on the north side of the Olympic Peninsula.

There were two outstanding features of the Cortinarius-flora of the Olympics in 1941. The first was the surprising number of previously undescribed Cortinarii encountered and the second was the abundance of carpophores produced by both the new and previously known species. Since Cortinarius unquestionably dominated the agaric flora during that season, it appeared desirable to compare the number of species found in the Olympics in 1941 with the number included in the most complete work yet published on the genus for North America, that of Kauffman (1932). In this monograph Kauffman included 202 species for North America. The total number collected and either identified or described as new from the Olympics in 1941 is 101 species.

When considering these figures, however, it should be kept in mind that, as of the time this paper is published, considerably more than 202 Cortinarii are known from North America. However, this is balanced in part by the fact that not all the Cortinarii collected in the Olympic area in 1941 were either identified or described. The majority of the collections were made within a period of five weeks, and in that time species of many other

[1] The field work was made possible by a grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

genera also demanded attention. In the following summary, the species (of Cortinarius) are arranged according to subgenera.

MYXACIUM. New species and varieties: *C. castaneicolor*, *C. griseo-violaceus*, *C. luteo-brunnescens* and *C. collinitus* var. *olympianus*. Previously described species: *C. pseudo-salor* Lange, *C. emunctus* Fr., *C. citrinifolius* Smith, *C. elatior* Fr., *C. mucigineus* Peck, *C. pallidifolius* Smith, *C. salor* Fr. and *C. vibratilis* Fr. Total: 12 species and varieties. Kauffman included only 15 for North America.

BULBOPODIUM. New species: *C. albescens*, *C. pseudo-arquatus*, and *C. subolivascens*. Previously described species: *C. calochrous* Fr., *C. cedretorum* Maire, *C. glaucopus* Fr., *C. metarius* Kauff., *C. montanus* Kauff. *C. multiformis* Fr., *C. olympianus* Smith, *C. orichalceus* Fr., *C. Parksianus* Smith, *C. prasinus* Fr., *C. purpurascens* Fr., *C. rapaceus* Fr., *C. scaurus* Fr. and *C. subpurpurascens* Fr. Total: 17 species. Smith (1942) included 48 species in his key. Kauffman, 1932, included 34.

PHLEGMACIUM. New species: *C. mutabilis*, *C. subfoetidus* and *C. superbus*. Previously described species: *C. anfractus* Fr., *C. balteato-cumatilis* Henry, *C. cliduchus* Fr., *C. crassus* Fr., *C. latus* Fr., *C. percomis* Fr., *C. substriatus* Kauff., *C. turmalis* Fr., *C. variicolor* Fr. and *C. varius* Fr. Total: 13 species. Kauffman recognized 29 from North America.

INOLOMA. New species: *C. fragrans*. Previously described species: *C. caesiifolius* Smith, *C. callisteus* Fr., *C. cotoneus* Fr., *C. pinetorum* (Fr.) Kauff., *C. pseudo-bolaris* Maire, *C. pyriodorus* Kauff. *C. turgidus* Fr. and *C. violaceus* Fr. Total: 9 species. Kauffman recognized 31 from North America.

DERMOCYBE. No new species. Previously described species: *C. anomalus* Fr., *C. cinnamomeus* Fr., *C. croceifolius* Pk., *C. malicorius* Fr., *C. phoeniceus* var. *occidentalis* Smith, *C. sanguineus* Fr., and *C. semisanguineus* Fr. *C. phoenicius* var. *occidentalis* was very rare in 1941 in the same places where it was abundant in 1935. Total: 7 species. Kauffman recognized 22 species.

TELAMONIA. New species and varieties: *C. angelesianus*, *C. boulderensis*, *C. mucicola*, *C. subcuspidatus*, *C. subpurpureus*, *C. distans* var. *olympianus*, *C. hemitrichus* var. *americanus*, *C. nigrellus* var. *occidentalis*. Previously described species: *C. adustus* Pk., *C. bibulus* Quél., *C. brunneus* Fr., *C. deceptivus* Kauff., *C. flexipes* Fr., *C. gentilis* Fr., *C. glandicolor* var. *curtus* Lange, *C. haematochelis* sensu Bres., *C. helvolus* Fr., *C. impennis* Fr., *C. incisus* Fr., *C. laniger* Fr., *C. Morrisii* Pk., *C. plumiger* Fr., *C. punctatus* Fr., *C. rigidus* Fr. and *C. stemmatus* Fr. Total: 25 species and varieties. Kauffman reported 39.

HYDROCYBE: New species: *C. cacao-color*, *C. fusco-discus*, *C. subacutus*. Previously described species: *C. acutus* Fr., *C. colus* Fr., *C. cypriacus* Fr., *C. dilutus* Fr., *C. erythrinus* Fr., *C. fasciatus* Fr., *C. firmus* Fr., *C. germanus*

Fr., *C. illuminus* Fr., *C. irregularis* Fr., *C. miniatopus* Lange, *C. privignus* Fr., *C. pulcher* Peck, *C. scandens* Fr. and *C. uraceus* Fr. Total: 18 species as compared to 34 reported by Kauffman.

MYXACIUM

Cortinarius castaneicolor sp. nov.

Plate 1

Pileus 4–9 cm. latus, convexus vel subplanus, glutinosus, fibrillosus, castaneo-rufus, ad marginem pallide alutaceus; lamellae caesiae dein pallidae, angustae, confertae; stipes 8–11 cm. longus, 10–15 (20) mm. crassus, clavatus, pallidus, sursum sericeus, deorsum zonatus; sporae 8–10×4.5–5.5μ.—Specimen typicum A. H. Smith n. 17,926, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 15, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 4–9 cm. broad, broadly convex with an inrolled margin, becoming plane or nearly so, glutinous when wet, ordinarily merely viscid, more or less appressed fibrillose beneath the gluten, the disc soon covered with minute patch-like scales, merely fibrillose streaked toward the margin, "hazel" on disc, "pinkish buff" toward the margin, finally becoming "chestnut" on disc and "cinnamon-buff" along the margin (disc dark chestnut-reddish, the margin buff to alutaceous); flesh 10–18 mm. thick at the stipe and tapered more or less abruptly to the margin, tinged caesious at very first but soon near "pale pinkish buff" (yellowish) or darker if water-soaked, unchanging when bruised, odor none, taste mild; lamellae "pallid purple-drab" (dull caesious) before the buttons open but soon becoming pallid and finally near "Sayal brown" (dull cinnamon), narrow (5–7 mm.), equal, adnate and toothed or adnexed, close, ±81 reach the stipe, 2 tiers of lamellulae, edges even; stipe 8–11 cm. long, 10–15 (20) mm. at apex, narrowly clavate, bulb 20–25 mm. thick, solid, pallid to pale watery buff within, surface white to whitish, apical region appressed silky, cortina white and scanty, lower portion decorated with scattered remnants of a universal veil, the remnants pale tawny and drying dull vinaceous brown, outer surface of the veil slightly gelatinous at first but all traces of viscidity soon lost.

Spores 8–10×4.5–5.5μ, slightly inequilateral, dull tawny under the microscope, the exospore slightly wrinkled; basidia four-spored; cheilocystidia if present no larger than basidia; gill trama subparallel, nearly hyaline in KOH; pileus trama homogeneous beneath a gelatinous pellicle of dull vinaceous brown hyphae (when revived in KOH), tramal body nearly hyaline when revived.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941, Stuntz and Smith 17,780a; Oct. 15, Smith 17,926-type.

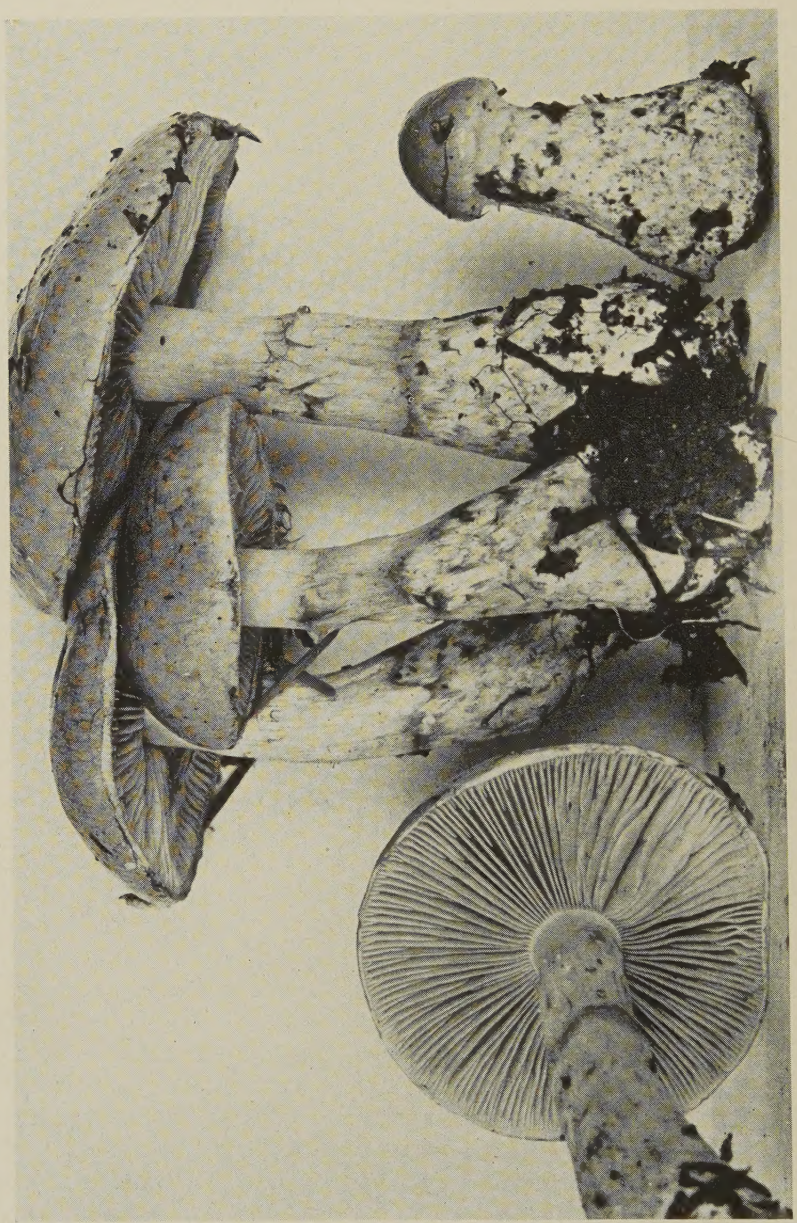

PLATE 1.—*Cortinarius castaneicolor* Smith, ×1.

Observations: Very good button stages were obtained in the type collection and a thin gelatinous sheath was found to extend from the margin of the pileus over the clavate portion of the bulb. Beneath this thin coating occurred the colored fibrils which leave the pale tawny remains mentioned in the description. In drying these become similar in color to the gelatinous hyphae forming the pellicle of the pileus. The remains of the viscid veil are quite easily washed away in prolonged wet weather with the result that one would not think of searching in Myxacium for the species. In stature the carpophores are similar to *C. pallidifolius*, but differ markedly in the color of the pileus, smaller spores and in having an almost dry stipe at maturity. *C. maculipes* Pk., a species of Phlegmacium, from its description appears to be quite similar to *C. castaneicolor*. I have examined its spores but have no notes on the appearance of the type. The spores of the two are alike, but from the description, it appears unlikely that my species can be referred to Peck's. The pileus of *C. castaneicolor* becomes darker in age instead of paler, a difference which appears significant. Peck compared the spots on the stem of *C. maculipes* to those of *Armillaria megalopus* Bres. In *C. castaneicolor* they are not that conspicuous. Peck did not mention caesious tints in either the flesh or gills of his species, and described the flesh as whitish. In *C. castaneicolor* the flesh when not caesious was distinctly yellowish. These differences in addition to the subviscid stipe appear sufficient to distinguish the latter.

Cortinarius griseo-violaceus sp. nov.

Plate 2

Pileus 3–6 cm. latus, convexus vel umbonatus, viscidus dein siccus, fibrillosus, griseo-violaceus; lamellae pallide violaceo-griseae, confertae, latae; stipes 6–10 cm. longus, 10–15 mm. crassus, aequalis vel subclavatus, pallide violaceus, deorsum viscidus et demum maculatus; sporae 7–9 (10) ×5–6μ, subellipsoideae.—Specimen typicum A. H. Smith n. 17,228, legit prope Heart O' Hills, Mt. Angeles, Olympic Mts., Wash., Sept. 24, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 3–6 cm. broad, convex, becoming broadly umbonate or nearly plane, the margin inrolled, surface viscid at first but soon dry and appearing appressed fibrillose, color "pale olive-gray" to "Quaker drab" when fresh (pale grayish violaceous), in age silvery violaceous, the margin sometimes "pallid neutral gray," often with sordid olivaceous-brown spotlike scales around the disc from the dried gluten; flesh "pale neutral gray" (pale violaceous gray) and watery, thick on the disc, abruptly tapered toward the margin, fading to "pale vinaceous-fawn" (pallid with a vinaceous tinge), brittle, taste mild, odor faintly fragrant; lamellae "ecru drab" (pallid violaceous gray) young, nearly "wood brown" at maturity, adnate or becoming adnexed, close, 62–66 reach the stipe, 1–2 tiers of

PLATE 2.—*Cortinarius griseo-violaceus* Smith, ×1.

lamellulae, moderately broad, edges even or somewhat eroded; stipe 6–10 cm. long, 10–15 mm. thick at the apex, clavate when young, nearly equal in age, solid, pale violaceous within, fading to whitish, surface at first

coated with appressed white fibrils up to the evanescent zone left by the ruptured cortina, silky near the apex, pale violaceous above, pallid to grayish violaceous below, at first the clavate portion covered by a very thin gelatinous sheath which soon becomes ruptured and discolors to form sordid brownish zones or patches, in wet weather the gluten sometimes becoming completely washed away.

Spores subellipsoid 7–9(10)×5–6μ, rusty brown in KOH, roughened; basidia four-spored; cheilocystidia inconspicuous and basidia-like or smaller; gill trama subparallel, nearly hyaline or slightly brownish in KOH; pileus trama with a pellicle of subgelatinous hyphae 3–5μ thick, beneath it a region of somewhat inflated hyphal cells, the remainder filamentose, pallid to somewhat brownish in KOH.

Cespitose to gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 22, 1941 (17,151); Mt. Angeles, Olympics, Wash., Sept. 24 (17,228-type), Sept. 26 (17,306); Oct. 20 (18,067).

Observations: This species presented one of the most curious problems yet encountered in my study of Cortinarii. The fungus closely resembles *C. alboviolaceus* of the subgenus Inoloma in practically all characters with the exception of the viscid pileus and stipe. Both have a similar cuticle over the pileus, and in both the upper layer of slender hyphae appears to be at least subgelatinous in KOH. At the time coll. 17,151 was made I could not be sure of the subgenus, whether to place it in Myxacium, Phlegmacium or Inoloma, even though the material at hand was in perfect condition. Later, in no. 17,228 careful observations were made in the field on over one hundred fruiting bodies and a thin evenly distributed gelatinous universal veil was found to cover the button stages. This soon broke up into patches or zones as the carpophores expanded. These observations were verified a second time (coll. 17,306) two days later. Hence the species is placed in Myxacium in spite of the resemblance to *C. alboviolaceus*. Prolonged wet weather may cause some species of Inoloma to become viscid to the touch, see Smith (1939), but it could not produce the gelatinous universal veil described above. In truly viscid species the only effect produced by prolonged wet weather is to wash off the remains of the veil thus leaving the stipe merely moist. *C. alboviolaceus* was not encountered in the Olympics in 1941, but fresh material has been studied from Michigan (Kauffman and Smith 1933), and Nova Scotia (Smith and Wehmeyer, 1936). *Phlegmacium cumatilis* (Fr.) Ricken is apparently a more robust species with spores 10–12×5–6μ, and with quite different stipe-characters. *Phlegmacium croceocaeruleum* sensu Ricken has a very slimy-viscid pileus and a dry stipe, see Smith (1939) (as Cortinarius).

C. Lebretonii Quél. is described as slightly viscid but is apparently a form of *C. spilomeus*, see Konrad and Maublanc (1924–32). *C. griseo-violaceus* does not have any highly colored veil remnants. The discoloration observed

was caused by drying gluten. Consequently, although the descriptions may seem to indicate some similarity, there appears to be no close relationship. *C. epipolius* Fr. is said to lack violaceous tints in the gills. Rea (1926) has given the spores as 8–9×6–7μ and subglobose. He described the stipe as whitish, but becoming violet, and made no mention of discolored zones from the gluten. All of these characters taken together indicate that *C. griseo-violaceus* is distinct. Such typical species of Myxacium as *C. iodioides* and *C. iodes* have very glutinous stipes and pilei, and *C. oregonensis* differs sharply in the color of its gills and in the pileus becoming yellowish on the disc. *C. griseo-lilacinus* Britz. appears to be closest to the Olympic species. The reddish ring on its stipe as described may not be significant. It probably represents the color of the fibrillose zone left by the cortina after large numbers of spores have accumulated upon it. However, if one disregards this character, it appears that *C. griseo-lilacinus* is indistinguishable from *C. iodes*, and I am inclined to consider it a synonym of the latter. *C. griseo-violaceus* differs apparently, in having a very thin gelatinous veil that leaves discolored zones on the stipe, and apparently in having dull violet gray instead of lilac colors throughout the pileus, gills and stipe.

Cortinarius luteo-brunnescens sp. nov.

Plate 3

Pileus 4–6 cm. latus, convexus, glaber, viscidus, flavidus; caro pallide lilacina demum pallida; lamellae caesiae, confertae, latae; stipes 7–9 cm. longus, 10–15 mm. crassus, clavatus, sursum lilacinus vel caesius, deorsum pallidus, viscidus, demum luteo-balteatus; sporae 7–9×4.5–5.5μ, subamygdaliformes.—Specimen typicum Stuntz and Smith n. 17,785, prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 4–6 cm. broad, convex, becoming broadly convex, surface glabrous and glutinous when fresh, soon appearing appressed fibrillose beneath the gluten and the disc breaking up into minute patchlike scales, becoming fibrillose-streaked near the margin, color "antimony yellow" to "warm buff" on the disc (bright to dull yellow), "straw yellow" on the margin, in age "chamois" (paler and duller) over the disc and "cream buff" (dull yellowish) along the margin, when dried "Verona brown" (dull vinaceous brown) over the disc and only slightly paler outward, the margin sometimes fibrillose when the center has become spotted with scales; flesh 8–12 mm. thick, tapered to the margin, tinged "pallid vinaceous drab" (pale dull lilac) when young, soon whitish, odor none, taste mild, no color change when cut; lamellae "pale Quaker drab" (dull violet) in partly expanded pilei, soon "avellaneous" and finally pale cinnamon brown, close, 72–76 reach the stipe, 2 tiers of lamellulae, broad (5–7 mm.) edges even or crisped;

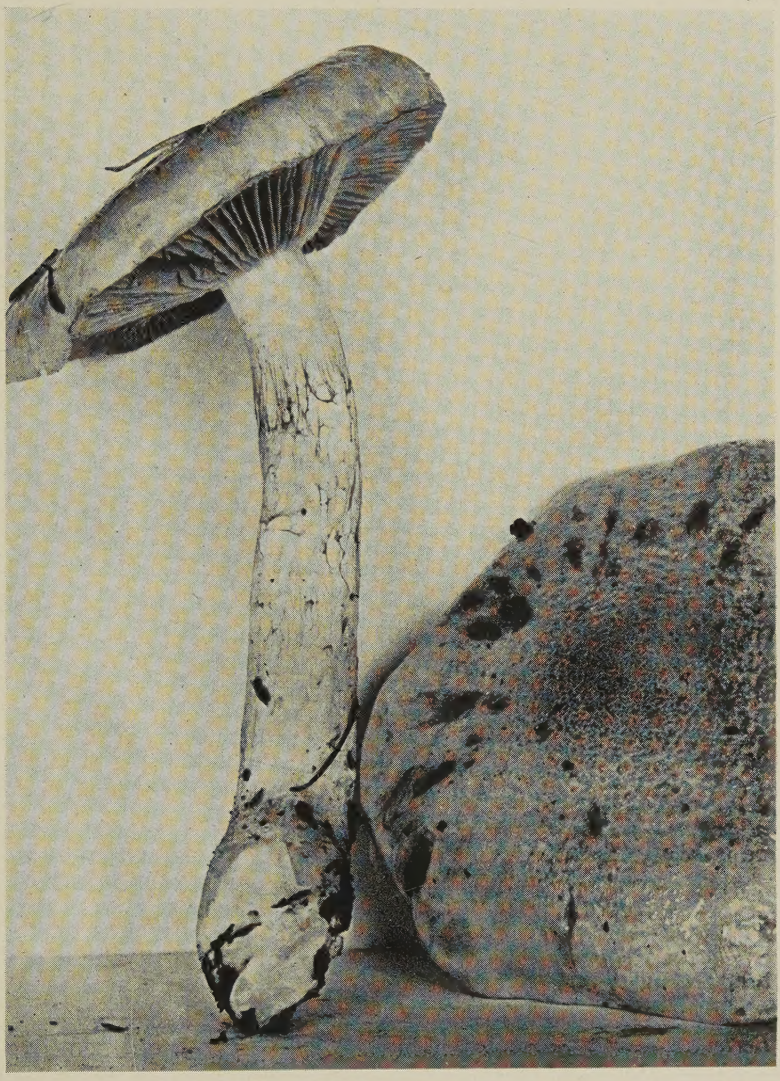

PLATE 3.—*Cortinarius luteo-brunnescens* Smith, ×1.

stipe 7–9 cm. long, 10–15 mm. at apex, clavate, solid, becoming hollow, apex concolorous with young gills and like them quickly fading, surface whitish, lower half stained with concentric zones of "antimony yellow" gluten, universal veil thin and gelatinous, at first evenly distributed over the lower part of the stipe.

Spores 7–9×4.5–5.5μ, subalmond-shaped, slightly roughened, rusty brown under the microscope; basidia four-spored; cheilo- and pleuro-

cystidia not differentiated; gill trama nearly hyaline in KOH, slightly interwoven; pileus trama homogeneous beneath a gelatinous pellicle, nearly hyaline in KOH.

Gregarious to scattered under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941, Stuntz and Smith no. 17,785-type and on Oct. 15, Smith (17,925).

Observations: When they were discovered I mistook the carpophores for *C. delibutus*. The spores at once distinguish fresh material, however, and dried specimens can be readily separated by their colors. Those of *C. delibutus* are yellow when dried whereas those of *C. luteo-brunnescens* are dull brown to almost vinaceous brown. Since the manner in which Cortinarii dry is very distinctive for many of the highly colored species, *C. luteo-brunnescens* appears to be more than just a variety of *C. delibutus*. *Phlegmacium decolorans* as described by Ricken is said to have a shiny stipe when dry. However, even old specimens of *C. luteo-brunnescens* in which the gluten on the stipe had dried, could be readily distinguished from it by their small spores.

Henry (1938c) has given a detailed account of *C. delibutus* in which he commented on the extreme variability of the species and the inconstancy of such characters as the color of the pileus, gills and stipe and also the sporadic presence of cheilocystidia. Among the species he placed in synonymy with *C. delibutus* is *C. sphaerosporus* Pk. In a previous paper (Smith, 1939) the latter was reported from western United States. However, I am now convinced that Peck's species is nothing more than a slight color variation of *C. delibutus*. Both have the characteristic yellow color in the pileus when dried. A curious feature of some variable species of agarics such as this one is that, although the colors of fresh carpophores may be quite different, when dried they are all nearly identical in color. This is also true for such agarics as *Hygrophorus laetus* Fr. Dried carpophores of *C. delibutus* show some variation in the intensity of yellow present if young caps are compared with old ones, and, of course, allowances for this variation must be made when comparing different collections.

C. Berlesianus Sacc. and Cub. (*C. tricolor* Pk. nec Mont.) has the spores of *C. delibutus* and very likely is a synonym of that species (Henry, 1938c). I have examined the spores of the type but did not actually compare dried specimens of both. *C. illibatus* Fr. is said to have reddish dots on the stipe. Its spore size appears to be an open question, but neither that of Massee (15–16×6–7μ) nor that of Bataille (7–9μ subglobose) fits my collections. *C. subglutinosus* Karst. is said to have spores 10–13 ×6–8μ and lacks lilac or violaceous tints in any part. No information on its color change (if any) undergone in drying appears to be available so no comparison can be made on that point.

CORTINARIUS COLLINITUS Fr., Syst. Myc. 1: 248. 1821. var. TYPICUS

Plate 4

Pileus 5–7 cm. broad, convex to plane or with the margin turned up in age, glabrous and very glutinous, when young "antimony yellow" on the disc and tinged pale caesious toward the margin, disc becoming darker and orange-rust color in age; flesh watery yellowish buff, odor none, taste not recorded; lamellae "pale lobelia violet" when nearly mature, paler violaceous when young, finally "Verona brown" (dull reddish brown), close, adnate with a tooth, moderately broad; stipe 10–12 cm. long, 10–15 mm. thick, equal or slightly tapered at the base, solid, flesh white or pallid, not lutescent in age or when bruised, the lower two thirds covered by a thick pale violaceous glutinous sheath, the lower portion becoming ruptured into more or less concentric violaceous to pallid bands or patches made up in part by the dense white fibrillose layer beneath the gluten and the other part by the gluten itself, the inner white-fibrillose layer terminating in a broad silky-fibrillose apical zone.

Spores 12–15×7–8μ, broadly almond-shaped, rusty brown under the microscope (in KOH) and with a distinctly roughened or wrinkled exospore: basidia 30–36×9–11μ, four-spored; pleurocystidia not differentiated; cheilocystidia basidia-like (and very likely merely immature basidia); pileus trama with a thick hyaline gelatinous pellicle.

Scattered under ponderosa pine, Cave Junction, Ore., Nov. 29, 1937 (8190), and Kerby, Ore., Nov. 26 (9095).

Observations: Since agaric nomenclature officially starts with Fries' Systema Mycologicum, vol. 1, 1821, controversial names such as *C. collinitus* should either be abandoned or interpreted in a manner consistent with the official description. Fries' (1821) diagnosis reads as follows:

"pileo carnoso laevi aurantio-fulva, lamellis purpurascentibus, dein ferrugineis, stipite transversim in squamas coerulescentes getinosus rupto" ("getinosus" is apparently a misprint for gelatinosus).

It is evident from this that the important characters of the species are the bluish transverse scales of the stipe and the color of the gills and pileus. Since the above collections corresponded very well in these respects they are here regarded as typical for the species. To judge from the literature as well as my own field experience, the typical variety is seldom encountered. On the other hand, certain of the varieties are very common and it is no wonder that different investigators have disagreed on the exact characters of the species. Henry (1938c) has recognized *C. collinitus* as a composite species made up of a series of slightly differentiated populations which he has designated in part at least as varieties. His concept is consistent with the original Friesian description, consistent with general usage and in line with the conditions set down by the International Rules of Nomenclature for determining the choice of names. Kauffman's concept of *C. collinitus*

PLATE 4.—*Cortinarius collinitus* var. *typicus* Fr., ×1.

cannot justifiably be maintained since the species to which he applied the name does not have the essential character called for in Fries' original description.

Henry, however, considers *Cortinarius trivialis* Lange as the typical form of *C. collinitus*. This is not consistent with Fries' original description. *C. trivialis* (*C. mucifluus* Fr. sensu Kauff. in part at least) lacks the violaceous

color in the gills and stipe. The specimens here described as var. *typicus* possess these colors. I have collected *C. trivialis* on many occasions and now consider it a variety of *C. collinitus* (**C. collinitus** var. **trivialis** (Lange) comb. nov. = *C. trivialis* Lange "Studies," pt. 10: 24. 1935), distinguished by its pallid gills, smaller spores and the sordid brownish to yellowish brown color assumed by the lower part of the stipe in age. The fungus described by Henry (1938c) as having amethyst gills at first and slightly violaceous tints in the gluten of the stipe also occurs near Ann Arbor. It comes up regularly in an aspen-juniper grove during late August or early September. It also has the small spores and is here considered to represent a form of var. *trivialis*. (**C. collinitus** var. **trivialis** f. **repandus** (Ricken) comb. nov. = *C. collinitus* var. *repandus* Ricken, "Blätterpilze" p. 124, 1911). Ricken characterized the variety as macroscopically similar to *C. collinitus* but differing in having smaller spores (11–13×6–7μ). He characterized the latter as having "blau odor violettlich" gills and the stipe as "blaulich odor blass." Lange has described a form of var. *typicus* (under the name *C. collinitus*) with the large spores but pallid gills, and a somewhat lutescent or brunnescent stipe. Lange reports his *C. collinitus* from North America, in addition to Denmark, and describes the gill edge as devoid of cheilocystidia. This fungus is here designated as **C. collinitus** var. **typicus** f. **caeruliipes** f. nov. (*C. collinitus* Fries sensu Lange, Flora Agaricina Danica, pl. 88, fig. B.)

Still another variety has been found in the conifer forests around Olympic Hot Springs in the Olympic National Park. The description follows:

Cortinarius collinitus var. **olympianus** var. nov.

Pileus 3–6 cm. latus, glutinosus, pallide alutaceus demum subpallidus; lamellae pallidae; stipes 7–10 cm. longus, 9–12 mm. crassus, glutinosus, pallidus; sporae 12–14.5×6–7.5μ.—Specimen typicum A. H. Smith n. 17,437, legit prope Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 3–6 cm. broad, obtuse, expanding to broadly convex or plane, the margin sometimes broadly uplifted making the disc appear depressed, surface very glutinous, the margin somewhat plicate-striate beneath the gluten, "clay color" when young (dull yellowish brown) but soon becoming "pinkish buff" (buff) at least along the margin and finally pallid more or less overall; flesh 10 mm. ± in the disc, tapered abruptly to the margin, soft, pallid brownish to whitish, odor none, taste mild; lamellae pallid when young (not clear white), soon "clay color" and in age nearly ochraceous tawny, broad (8 mm. ±), adnate but developing a slight decurrent tooth and becoming adnexed, moderately close (52–58 reach the stipe, 2 tiers of lamellulae), edges uneven; stipe 7–10 cm. long, 9–12 mm. at the apex, equal or very slightly and evenly enlarged downward, pallid within,

solid, surface glutinous and whitish, a thick white cottony layer of appressed fibrils from the partial veil present beneath the gluten, as the gluten dries this layer becoming broken up into relatively few (3–5) pallid broad subannular zones, upper half merely appressed silky.

Spores almond shaped, 12–14.5×6–7.5μ, rusty brown, with a wrinkled exospore; basidia four-spored; cheilocystidia not differentiated; pleurocystidia none seen, gill trama nearly pallid in KOH, somewhat interwoven; pileus trama with a thick layer of slender hyaline gelatinous hyphae over the surface, beneath it a layer of enlarged hyphae (pseudo-parenchymatic in tangential section), the remainder floccose and more or less filamentose.

Gregarious under fir, Olympic Hot Springs, Olympic National Park, Wash. Sept. 30, 1941 (17,437).

Observations: This variety differs from *C. elatior*, in company with which it was growing, in having pale colors over all in age and in lacking cheilocystidia as well as violaceous tints. It appears very close to *C. mucifluus* sensu Lange but lacks cheilocystidia. It is separated from the other varieties of *C. collinitus* by the pale colors in age, the less scaly stipe, and lack of violaceous tints on the gills and stipe when young.

The following key is given to aid in recognizing the forms and varieties of *C. collinitus*. *C. collinitus* var. *pumilis* sensu Henry is more appropriately attached to *C. mucifluus* as a variety because of its large cheilocystidia.

A. Spores 12–15μ long.
   1. Both gills and stipe lilac to violaceous ..... Var. *typicus*
   2. Gills pallid, stipe violaceous ..... Var. *typicus* f. *caeruliipes*
   3. Gills pallid, stipe pallid, cap very pale in age ..... Var. *olympianus*

B. Spores 10–13μ long.
   1. Gills pallid to yellowish, stipe brunnescent below ..... var. *trivialis*
   2. Gills and stipe tinged violaceous at first ..... Var. *trivialis* f. *repandus*

CORTINARIUS CYLINDRIPES Kauff., Bull. Torr. Bot. Club 32: 321. 1905.

The collection designated by Kauffman as the type of the species is the one from which his published description was drawn and the one from which his published photograph was taken. It was found under hemlock near Ithaca, New York in 1904. In his material now in the University of Michigan Herbarium are several additional collections from the same locality. The type consists of two fruiting bodies in rather poor condition. They were fairly well dried, but apparently rather badly damaged during the process by insect larvae. However, good sections of the gill edges were obtained and mature spores were abundant. No differentiated cheilocystidia were found, although basidia, both mature and immature, covered the edges of the gills. The immature basidia might possibly be mistaken for small cheilocystidia by an inexperienced observer. The spores measure 13–17×5–7.5μ. Kauffman described them as 12–15μ long, and in his notes on the collection remarked that spores from gills which were still violaceous

measured 1–1.5μ shorter but were typical as to shape and color. Several of Kauffman's Ithaca collections were examined and all were observed to have the same microscopic characters.

When studying agarics under Kauffman in 1929, *C. cylindripes* was the first Cortinarius I identified. The specimens studied *had* spores 12–15×6–8μ as per Kauffman's description, and he verified the identification stating that the material was typical in every respect. Since then this particular fungus has been found repeatedly in the vicinity of Ann Arbor. It grows in low open oak woods under brush at the edges of wet depressions, swamps or bogs. The gill edges are characterized by numerous inflated "balloon-shaped" cystidia. These are so abundant that the gill edge is practically sterile and "heteromorphic." The spores from deposits consistently measure 12–15×6–8μ. This fungus is clearly distinct from the type of *C. cylindripes* by its shorter spores and abundant cheilocystidia. The species reported as *C. cylindripes* from Nova Scotia by Smith and Wehmeyer (1936) is apparently the same as the type. The single preserved specimen is very young, and no cheilocystidia are present. The spores are only 15μ long, but this, more than likely, is due to the immaturity of the carpophore, and is in line with Kauffman's observations on the size of spores taken from young gills.

In his comments on *C. cylindripes*, Kauffman (1918, p. 331), stated that he considered a similar European species having spores 14–18μ long to be the original *C. collinitus* of Fries. An examination of the fruiting bodies he collected when he was in Sweden in 1908 and identified as *C. collinitus* shows that they have spores 13–17×5–7.5μ and that they lack cheilocystidia. In fact, these carpophores appear to be identical with his Ithaca collections in every respect. When spores of the type were compared with those of the Stockholm collection, no significant differences could be found. Pale, long and nearly smooth spores (apparently abnormal) are more frequent in the Swedish collection than in the type of *C. cylindripes* but they can be found in both. Since this study has removed the only difference which Kauffman himself found between the two, I have no hesitation in referring all the collections concerned to *C. cylindripes*. Since the type is definitely not a mixture of species, and since his description was taken from it, the published spore size must be considered an error of observation. His statement in the original description that the basidia are 10μ long, is a typographical error. The basidia are about 30×10μ.

The question of what names to apply to these two species must now be considered. The name *C. collinitus* must be ruled out of consideration here if one adheres to the International Rules of Nomenclature. Rightly or wrongly we must start from vol. 1 of Systema Mycologicum, and, as already pointed out (see discussion of *C. collinitus*) the name "collinitus" must be applied to a Cortinarius with the transverse scales or zones over

the base of the stipe. In many instances in which the descriptions in Systema are very brief and general it appears logical to place the greater emphasis on the later more detailed accounts by Fries. However, when the description in Systema does contain the key character, it does not appear justifiable to try to establish under a given name a plant *without* that key character. Thus the name "collinitus" must be applied to a fungus having the transverse zones over the lower part of the stipe, and cannot be applied to *C. cylindripes*. *C. cylindripes*, then, is a species of conifer regions both in North America and Scandinavia characterized by its large spores, violaceous colors throughout in the very young stages and lack of cheilocystidia.

Lange (1938) has apparently described the other species under the name *C. pseudo-salor*. The spores and cheilocystidia appear to be identical. His description of the macroscopic characters, however, was apparently based on limited material (he states that he found it but once), and so such characters as the bluish violet edge of the gills, their transversely veined surfaces, and flush of light violaceous blue in the stipe must be interpreted with some latitude. The following is a description of *C. pseudo-salor* as I have found it in southern Michigan:

CORTINARIUS PSEUDO-SALOR Lange

Pileus 3–9 (10) cm. broad, convex to gibbous, becoming plane or umbonate, surface very glutinous, appearing as if varnished in dry weather, glabrous, or with veil remnants along the margin, color lavender to dull violaceous over all when young, sometimes becoming "army brown" (dull reddish brown) over all except the violaceous margin, usually becoming paler and yellowish, sometimes violaceous umber at first, margin often translucent striate when moist and frequently sulcate to longitudinally wrinkled; flesh thick on the disc, violaceous but soon pallid, odor and taste not distinctive, lamellae dull violet to lavender when young, slowly becoming cinnamon brown, emarginate or at first bluntly adnate, moderately broad (5–8 mm.), rather close, edges white floccose and often uneven, sometimes crisped, faces smooth to rather strongly veined; stipe 7–12 cm. long, 6–15 mm. thick, covered with a thick gelatinous sheath to near the apex, equal, solid, dull violaceous to lavender, gradually fading to pallid, apex silky to appressed fibrillose, sheath not breaking up into transverse zones as in *C. collinitus*, often with an apical fibrillose zone from the broken cortina.

Spores 12–15×6.5–8μ, broadly almond-shaped, roughened, dark rusty in KOH; basidia four-spored, 28–36×9–11μ; cheilocystidia very abundant, 24–32×10–18μ, ballloon-shaped, thin walled, occupying the entire gill edge. Pileus with a gelatinous pellicle.

Common under oaks in low open woods and under brush at edges of bogs, July and August.

A single specimen was found under conifers on Mt. Angeles, Olympic Mts., Wash., Oct. 7, 1941 (17,612) which apparently belongs here. The pileus was "cinnamon-buff" (yellowish) on the disc and "pale grayish vinaceous" toward the margin. The flesh was pale grayish vinaceous near the gill margin and "dull lavender" elsewhere. The lamellae were "pale vinaceous lilac" before the spores obscured the original color. The stipe was 12 cm. long, 15 mm. thick at the apex and nearly equal. It was "dull lavender" in the cortex near the apex but paler below, and the glutinous sheath was lavender. The spores measure 11–14×6.5–8μ, and the cheilocystidia were found to be only slightly inflated (6–12μ).

Although not quite typical in its cheilocystidia, this find corresponds better with Lange's plate than many of the Michigan collections, and is particularly interesting because of its habitat. Apparently both *C. cylindripes* and *C. pseudo-salor* do occur under conifers. *C. elatior*, the most closely related species, lacks the pronounced violet colors of both *C. cylindripes* and *C. pseudo-salor*.

CORTINARIUS EMUNCTUS Fr., Epicrisis Syst. Myc., p. 275. 1838.

Pileus (4) 7–9 (12) cm. broad, convex to obtuse with an inrolled margin, becoming broadly convex or more or less umbonate, surface covered by a thick layer of gluten, dull lilac (more or less "pale purple-drab") over all when young, becoming very pale violaceous gray ("pallid mouse gray") or tinged olive-yellow over the disc, in age the entire surface usually changing to "olive-ochre" (olive-yellow) because of the changing gluten, appearing somewhat fibrillose-streaked beneath the gluten; flesh thick, soft, tapered abruptly away from the disc, pallid but soon tinged buff ("cinnamon-buff"), odor and taste not distinctive; lamellae pallid brownish young, near cinnamon brown at maturity, close, broad, adnate but becoming adnexed, edges slightly eroded; stipe 9–14 cm. long, 10–25 mm. at the apex, clavate and up to 4 cm. thick at the base at times, usually tapered to a point below the thickest portion, solid, pallid within except for a faint lilac tinge in the apex, apical third dry and silky fibrillose, tinged violaceous, glutinous over lower two thirds and also pallid violaceous gray, soon stained olive-yellow like the cap (at least near the base) from the drying gluten.

Spores broadly ellipsoid to subglobose, 6–7.5×4.5–6μ, slightly roughened; basidia four-spored; cheilo- and pleurocystidia not differentiated; gill trama nearly hyaline in KOH, somewhat interwoven; pileus trama homogeneous beneath a thick gelatinous pellicle.

Scattered to gregarious under mixed conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, (17,449); Oct. 15 (17,924); and Oct. 17, 1941 (17,990).

Observations: This species varies greatly in stature. The carpophores of

coll. 17,449 were very similar in stature and color to the illustrations of *C. emunctus* (Fries, 1877). The outstanding feature of the Olympic collections was the change in color to olive-yellow in age or after being collected and wrapped in waxed paper. The change takes place in the gluten of the pileus and stipe, and in dried material the pileus is about the same shade of yellow as that of *C. delibutus* (a dull or bright ochre yellow). Although the above collections showed differences in the amount of yellow assumed before collecting, after being properly dried the colors are the same. Since all the specimens were collected during a period of extremely wet weather, no information is available on the degree of color change taking place under more normal conditions. Neither is there any information available on the color of dried specimens of *C. emunctus* from Europe. Fries, however, did indicate that *C. emunctus* assumed yellowish and finally grayish alutaceous tints. Although the color in age according to Fries is obviously different from that observed in the Olympic collections and may well be significant, still it is close enough to lead one to suspect that it is only a variation. It appears best to identify my collection as the Friesian species at least until more information on the latter is available. *C. salor*, a species with the same appearance, can be readily distinguished by its violaceous gills, and *C. livido-ochraceus* Berk. is separated by its larger spores.

BULBOPODIUM

Cortinarius albescens sp. nov.

Pileus 4–9 cm. latus, obtusus vel subumbonatus, glutinosus, violaceo-griseus dein pallidus; sapor amarus; lamellae griseo-lilacinae, confertae, angustae, adnatae dein secedenti-liberae; stipes 6–12 cm. longus, 9–12 mm. crassus, deorsum marginato-bulbosus, sursum aequalis, obscure lilaceus demum pallidus; sporae 7–9 (10) × 5–6μ.—Specimen typicum A. H. Smith n. 17,522, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 1941; in Herb. Univ. of Mich. conservatum.

Pileus 4–9 cm. broad, obtuse with an incurved margin, in age the margin spreading, the disc slightly umbonate at first, umbo diappearing, surface glutinous and streaked with violaceous gray ("pale ecru drab") when young, quickly fading to whitish ("tilleul buff") but sometimes the disc becoming tinged "cinnamon-buff" (buff color), glabrous or with whitish fibrils from the universal veil; flesh thick in the umbo, abruptly thinner elsewhere, pallid, odor none, taste distinctly bitter; lamellae "grayish lavender" (dull lavender) young, becoming "Sayal brown" (dull cinnamon) at maturity, sometimes retaining a dull lavender hue, close to crowded, narrow, adnate, readily seceding, edges eroded; stipe 6–12 cm. long, 9–12 mm. thick, solid, equal, the base slightly bulbous and the upper edge of the bulb marginate at first, the marginate condition soon disappearing (as in *C. corrugatus*), flesh pale dull lavender throughout but soon pallid, un-

changing when bruised, surface at first concolorous with the young gills but soon whitish, thinly fibrillose from scattered veil remnants, glabrescent, universal veil scanty, remnants usually distributed around the bulb or lower part of the stipe.

Spores broadly almond shaped, 7–9 (10) × 5–6μ, roughened, dark tawny under the microscope; basidia four-spored; pleuro- and cheilocystidia none seen; gill trama parallel, hyaline or nearly so in KOH; pileus trama with a thick gelatinous pellicle, pallid brownish in the tramal body.

Singly or in groups of three or four under conifers, Olympic Hot Springs, Olympic National Park, Oct. 2, 1941 (17,522-type; 17,523 and 17,567); Oct. 8 (17,706); Oct. 11 (17,770); Oct. 15 (17,913); Storm King Mt. also in the Park, Oct. 16 (17,976); Olympic Hot Springs, Oct. 17 (18,008).

Observations: The dried pilei are pale to dark buff colored or have retained an avellaneous cast near the margin. Although related to *C. glaucopus* this species differs in its bitter taste, long white stipe at maturity, the violaceous gray pileus which fades to whitish, and in its manner of fruiting. *C. arcifolius* Henry is very close but differs in having a mild taste, larger spores, slightly different colors in the pileus, and in not having adnate-seceding gills. *C. elotus* Fr. is said to have an acrid taste (in Hymen. Europaei), but its gills apparently are not lavender at first. In many respects *C. elotus* of Fries seems to fall into the series of olivaceous forms around *C. glaucopus* commented upon previously (Smith, 1939). *C. albescens* does not have the variable colors attributed to *C. elotus* by Fries and does not fit into the above series. The above mentioned forms of *C. glaucopus* are very distinct from *C. albescens*. *C. canolilacinus* Britz. may be close to *C. albescens*, but judging from its description, it differs in not having violaceous gills. *C. intermedius* Rea should also be considered here, but is distinct by its almost entire lack of bluish tints. More than likely *C. intermedius* will be found to be identical with *C. albidus* Pk.

Cortinarius pseudo-arquatus sp. nov.

Pileus 5–11 cm. latus, convexus vel planus, viscidus, alutaceus vel fulvus; lamellae griseo-caeruleae, confertae, angustae vel sublatae, stipes 6–12 cm. longus, 10–25 mm. crassus, marginato-bulbosus, sursum griseo-caeruleus, deorsum pallidus, demum pallide alutaceus; sporae 11–14 × 6–8μ, subellipsoideae.—Specimen typicum A. H. Smith n. 17,141, legit prope Olympic Hot Springs, Olympic National Park, Wash., Sept. 22, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 5–11 cm. broad, hemispheric with an inrolled margin at first, expanding to broadly convex or obtuse, the margin long remaining inrolled, when finally expanded the margin often either wavy or sinuate, surface glabrous or usually with patches of fibrils adhering along the margin, viscid, buttons "Sayal brown" over all except the "cinnamon-buff" margin

(dull cinnamon on the disc, dull pale alutaceous along the margin), finally becoming more or less ochraceous tawny over the disc and the margin tinged avellaneous, in some the disc sometimes becoming "clay color"; flesh very thick and firm (up to 18 mm.), tapered abruptly, "tilleul buff" at first (pallid), hardly changing but in age finally yellowish buff, unchanging when bruised, odor and taste not distinctive; lamellae "endive blue" becoming "light Quaker drab" and finally more or less "tawny-olive" (pale grayish blue or rich caesious, slowly becoming brown), close to crowded 115±reach the stipe, 2 tiers of lamellulae, narrow to moderately broad (8 mm.±), bluntly adnate, becoming shallowly adnexed and developing a decurrent tooth, edges becoming eroded; stipe 6–12 cm. long, 10–25 mm. thick at apex, equal down to a broad flanged (not depressed) bulb 3.5–5 cm. in dia., base of bulb subconic and solid, interior of stipe pale violaceous in upper portion but soon pallid throughout and finally sordid brownish, surface tinged bluish gray at apex but soon sordid yellowish to brownish, pallid below when young, silky, veil remnants soon disappearing, sometimes leaving a faint fringe around the limb of the bulb but not volva-like; veil faintly caesious at first, soon whitish.

Spores 11–14×6.5–8μ, broadly subellipsoid, nearly smooth, very pale tawny under the microscope; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama subregular; pileus trama homogeneous beneath a thick gelatinous pellicle.

Gregarious to scattered under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 22, 1941 (17,141-type). Also material collected in the same locality in 1935 and reported as *C. arquatus* (Smith, 1939).

Observations: This species was originally identified as *C. arquatus* but as a result of additional data obtained in 1941 it appears best to consider it a distinct but closely related species. Since *C. arquatus* is not too well known in Europe, I have adopted the concept of Kauffman which is clearly in line with the Friesian descriptions. There is a distinct and constant difference between the spores of the above collections and Kauffman's material. In the latter they are amygdaliform, dark rusty under the microscope, and distinctly roughened. In *C. pseudo-arquatus* they are nearly ellipsoid, very pale brown in KOH under high magnification and nearly smooth. The colors of the pilei are also distinct, as can be readily ascertained by comparing the descriptions. In *C. pseudo-arquatus* the tendency for the flesh in the pileus and stipe to become yellowish is much less pronounced, in fact, it is almost lacking. This species is one of the larger Bulbopodia. It was observed in the woods around Olympic Hot Springs during late September and early October in 1941, and had more or less disappeared at the time the majority of the Cortinarii were at the peak of their fruiting cycle.

Cortinarius cyanopus is also very close to *C. pseudo-arquatus*. Henry (1935) has given a detailed account of the former in which the pellicle is

described as bitter, the spores as 9–11×6μ, the odor as fragrant, the color of the cap as pale creamy olivaceous and the gill edges as heteromorphic owing to the presence of numerous sterile cells (cheilocystidia). *C. pseudo-arquatus* does not correspond in any of these characters. My (1939) report of *C. cyanopus* from the Siskiyou Mts. of northern California was based on Kauffman's (1932) concept of the species. Its spore characters separate it from *C. pseudo-arquatus*, but it is properly placed in Bulbopodium.

Cortinarius subolivascens sp. nov.

Pileus (3) 4–7.5 cm. latus, late convexus dein planus, viscidus, obscure violaceo-griseus, demum subolivaceo- vel griseo-violaceus, glaber; lamellae caeruleae, confertae; stipes 3–5.5 cm. longus, 1–2 cm. crassus, marginato-bulbosus, subcaeruleus; sporae 9–11 (12)×5–6μ.—Specimen typicum A. H. Smith n. 14,311, legit prope Deer Lake, Olympic National Park, Wash. June 13, 1939; in Herb. Univ. of Mich. conservatum.

Pileus (3) 4–7.5 cm. broad, plane with a decurved and inrolled margin, becoming broadly convex to nearly plane in age, viscid, color more or less "deep Quaker drab" (deep violaceous gray) and mottled with watery streaks when fresh, fading slowly and becoming olivaceous gray to pale purplish gray, the disc not fading in some (colors very difficult to describe, olive, purple and drab in varying proportions); flesh pallid olivaceous gray in cap and apex of stipe (slightly violaceous in the cortex at the apex of the stipe when young), odor none, taste not recorded; lamellae "light dull bluish violet" (bluish) to "light purple-drab" (dull purplish) before becoming pale cinnamon-brown, adnate but rounded slightly, narrow to moderately broad (5–7 mm.), crowded, 125± reach the stipe, not staining when bruised; stipe 3–5.5 cm. long, 1–2 cm. thick at apex, equal to the flaring marginate base (as in *C. glaucopus*), tapered to a point at the base, surface covered by "light dull bluish violet" fibrils from the remains of the veil, pallid beneath the fibrils or "light dull bluish violet" at apex.

Spores 9–11 (12)×5–6μ, almond-shaped, roughened, dark rusty brown under the microscope; basidia four-spored; gill trama parallel, hyaline in KOH; pileus trama homogeneous beneath a gelatinous pellicle, tawny brown just beneath the pellicle in KOH.

Gregarious to subcespitose, under conifers, Deer Lake Trail, near Deer Lake, Olympic National Park, Wash., June 13, 1939 (14,311-type); Lake Angeles, Mt. Angeles, Olympics, Wash., June 25, 1939 (14,634).

Observations: This species is "cinnamon-buff" when dried (buff color). The change in color in drying, the violaceous gills and flanged base of the stipe indicate a close relationship to *C. glaucopus*, and enables dried specimens to be readily distinguished from those of *C. Parksianus*. *C. subolivaceus* differs from *C. glaucopus* in not becoming rusty brown while still fresh and in its larger spores. Typical *C. glaucopus* is very abundant during

September and October in this same area, and has been reported on previously, Smith (1939). Henry (1935) described *C. glaucopus* as having spores 8–11×6–6.5μ, but as not having a violaceous pileus. Typical *C. glaucopus* was examined in great quantity in the region around Olympic Hot Springs again during the season of 1941 and found to check exactly with the material described earlier Smith (1939). The small spores are distinctive but the colors of the pileus are very confusing. It is apparent that in Europe as well as in North America there are a number of slightly differentiated populations that may be regarded as either forms or varieties. Henry mentions three varieties of *C. glaucopus*, and I have observed several here in the United States. Because of the vernal fruiting habit of *C. subolivaceus*, its large spores and the dominant violaceous color of the pileus it is described here as a species. *C. glaucopoides* Kauffman appears to be a comparable species related to *C. glaucopus* but differs in the almost entire lack of violaceous tints.

Cortinarius orichalceus var. **olympianus** var. nov., f. **typicus**

Pileus 6–10 cm. latus, convexus vel planus, viscidus, olivaceo-luteus dein sordide vinaceo-brunneus; odor nullus; lamellae olivaceo-luteae, confertae, angustae; stipes 5–10 cm. longus, 1–2 crassus, pallide olivaceus; sporae 9–11×5-6.5μ.—Specimen typicum A. H. Smith n. 17,513, legit prope Olympic Hot Springs, Olympic National Park, Wash. Oct., 2, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 6–10 mm. broad, convex with an incurved margin, becoming broadly convex to nearly plane, very glutinous at least when young, disc soon broken up into areolate crustlike patches, appearing somewhat appressed fibrillose beneath the gluten along the margin, button stages "dark olive-buff" (pale olivaceous gray), sometimes almost entirely dark vinaceous brown in age; flesh thick, soft, pallid but soon becoming "deep olive-buff" (dark olivaceous) and when cut developing a pale lilac cast ("pale quaker drab") in the apex of the stipe and near the surface of the pileus, with a watery green line above the gills, odor none, taste not distinctive; lamellae "ecru olive" (fairly bright olive-green), becoming sordid rusty olivaceous in age, sometimes with a "pale Quaker drab" (dull lilac) tint near the cap margin, crowded, narrow, adnate, edges uneven to eroded; stipe 5–10 cm. long, 1–2 cm. thick at apex, solid, pallid within at first, then olivaceous gray and developing a faint lilac tint in some when cut, surface pale olivaceous and densely fibrillose from remains of the pale olivaceous veil, veil remnants becoming pallid, base with an abrupt marginate nondepressed bulb up to 4 cm. in dia. bulb conic to rounded below, soon staining dark reddish brown where handled.

Spores 9–11×5–6.5μ, somewhat almond-shaped, rusty brown in KOH,

with a distinctly wrinkled exospore; basidia four-spored, hyaline or with a faint purplish tinge in KOH; hymenium filled with basidia-like bodies having a fuscous-purplish opaque amorphous content; cheilocystidia not differentiated; gill trama parallel, hyaline to faintly purplish in KOH; pileus trama with a thick, gelatinous pellicle, homogeneous and nearly hyaline in KOH or irregularly staining dull purple.

Gregarious to scattered under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941 (17,513).

Observations: Several market baskets full of carpophores were collected Oct. 2. At that time it was the most abundant Bulbopodium in the region. The carpophores dried a dull sordid brown but after standing in contact with napthalene for several months their color was "seal brown" on the disc of the pileus and near "deep livid brown" (deep purple) on the bulb, stipe and margin of the cap. This change in color may have been caused by contact with the napthalene used as an insect repellant. The fungus described here is the *C. orichalceus* of Kauffman, and is distinct from the typical variety of the species in lacking a characteristic odor and in apparently having slightly smaller spores. Bresadola described the spores as 10–13×6–7μ and the flesh as having the odor of anise.

Cortinarius orichalceus var. **olympianus** f. **luteifolius** f. nov.

Pileus 5–9 cm. latus, convexus, olivaceo-luteus dein sordide cinnamomeus; lamellae pallide luteae; stipes non violaceus; sporae 9–11×6–7μ. —Specimen typicum A. H. Smith n. 16,970, legit prope Lake Angeles, Olympic Mts., Wash., Sept. 19, 1914; in Herb. Univ. of Mich. conservatum.

Pileus 5–9 cm. broad, broadly convex becoming nearly plane, the margin usually somewhat decurved and long remaining inrolled, very glutinous in wet weather, color "chamois" to "honey-yellow" over all at first (rich dull yellow or yellow tinged with olive), gradually becoming "Sayal brown" (dull cinnamon) on the disc, glabrous or appearing fibrillose-streaked beneath the gluten, disc developing small patchlike scales as the gluten dries; flesh thick, whitish but with a watery greenish line along the gills, odor none, taste perfectly mild; lamellae "deep colonial buff" (dull rather clear yellow), becoming "honey-yellow" (more of an olive-yellow) and finally dull rusty from the spores, close to crowded, 2 tiers of lamellulae, narrow (6–7 mm.), bluntly adnate and nearly equal, edges somewhat eroded; stipe 5–7 cm. long, 2–2.5 cm. thick at the apex, with a flanged nondepressed bulb up to 4 cm. broad, solid and pallid within but becoming pale olivaceous, surface more or less fibrillose from remains of the pale greenish yellow cortina, surface "marguerite yellow" (pale bright yellow) or paler, base sordid yellow and somewhat pointed, with numerous "marguerite yellow" rhizomorphs.

Spores 9–11.5×6–7μ, subalmond-shaped, rusty brown under the microscope, with a wrinkled exospore; basidia four-spored; basidia-like cells with amorphous purple-fuscous content rather rare; cheilocystidia none seen; gill trama hyaline but gradually becoming dull purplish red in KOH, subparallel; pileus trama homogeneous beneath a thick gelatinous pellicle, tramal body becoming purplish red in KOH at least in some places.

Observations: This form differs from the typical form in lacking the faint lilac tint in the apex of the stipe, in the pileus not becoming dark vinaceous red but instead merely dull cinnamon brown when fresh, and in the brighter yellow lamellae. The pilei of herbarium specimens are also paler, but the bulb is deep purplish as in typical material of the variety. The spores are also the same.

Cortinarius orichalceus var. **xanthocephalus** var. nov.

Pileus 4–6 cm. latus, convexus, viscidus, laete aurantio-brunneus; caro pallide caesia; lamellae olivaceo-ochraceae; sporae 8–10×6–7μ.—Specimen typicum A. H. Smith n. 17,514, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 4–7 cm. broad, (all young), convex with an inrolled margin, disc near "Xanthine-orange" (bright orange-brown), margin "amber-yellow" (clear full yellow), disc covered by minute crust-like scales beneath the thick gluten, margin at first fibrillose from the veil remnants; flesh thick, soft, "pallid mouse gray" (pale violaceous gray) or "pale mouse gray" in apex of stipe after being cut, pallid at very first, odor and taste not distinctive; lamellae bright "olive-ochre" (olivaceous yellow) but soon rusty greenish yellow, close but not crowded, adnexed, moderately broad, edges eroded; stipe 6–8 cm. long, 10–12 mm. thick at apex, solid, pallid when cut but then developing a lilac tinge in the cortex, surface "seafoam yellow" (pale yellow) and densely fibrillose from the veil remnants, veil faintly olivaceous yellow, bulb cylindric, the upper margin abruptly margined but not depressed, rusty yellow below and with pale yellow rhizomorphs.

Spores 8–10×6–7μ, somewhat almond-shaped, exospore wrinkled, rusty brown under microscope; basidia four-spored; hymenium with basidia-like bodies filled with dark amorphous contents; pleurocystidia not seen; cheilocystidia basidia-like; gill trama regular, hyaline to purplish in KOH; pileus homogeneous beneath a gelatinous pellicle which usually becomes dark purplish in KOH, tramal body also purplish in places when revived in KOH.

Cespitose in small clusters, Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941 (17,514).

Observations: The base of the bulb is deep purplish in the dried specimens, but the pilei have a somewhat ferruginous rather than fuscous-purple tint. The bright colors when fresh readily distinguish this variety

from var. *olympiana* f. *typica* and the small spores and more ferruginous pilei distinguish the dried specimens. Form *luteifolius* of var. *olympianus* appears to be somewhat intermediate, but lacks the faint lilac tint in the apex of the stipe and in addition has larger spores. Because of the color assumed by the bulb after drying, var. *xanthocephalus* cannot be referred to the series of Bulbopodia of which *C. fulgens* is the central species.

PHLEGMACIUM

Cortinarius caesiellus sp. nov.

Plate 5

Pileus 4–7 cm. latus, convexus vel obtusus dein planus vel umbonatus, viscidus, pallide alutaceus; lamellae pallide caeruleae demum griseo-caeruleae, confertae; stipes (4) 6–10 cm. longus, 8–15 mm. crassus, solidus, sursum caesius, deorsum pallidus et cum zonis subaurantiis 1–3 cinctus; sporae 7–9×6–8μ.—Specimen typicum A. H. Smith n. 18,823, legit prope Ann Arbor, Mich., Oct. 1, 1942; in Herb. Univ. of Mich. conservatum.

Pileus 4–7 cm. broad, convex or obtuse when young, in age plane or with a low umbo, the margin often remaining decurved and somewhat undulating, surface viscid when wet, glabrous or fringed with fibrils along the margin, color evenly "pinkish buff" (pale buff) or the disc slightly darker and pale alutaceous ("cinnamon-buff"); flesh thick, white, firm, odor and taste not distinctive; lamellae "light Payne's gray" (pale blue) becoming "pale drab-gray" and finally "clay color" (more or less alutaceous), adnate with a decurrent tooth, becoming slightly adnexed, moderately broad (6–8 mm.) equal, close; stipe (4) 6–10 cm. long, 8–15 mm. thick at the apex, solid, pale bluish drab in the apex when fresh, equal to somewhat clavate, dry, lower half with "orange-buff" (pale orange) zones or patches of fibrils, universal veil remnants sometimes disappearing in age, whitish and silky above, mycelium white.

Spores 7–9×6–8μ, broadly ovate to subglobose, roughened, dark rusty brown under the microscope; basidia four-spored, hyaline to pallid yellowish in KOH; cheilocystidia basidia-like or slender (only 3–5μ broad); pleurocystidia not differentiated; gill trama hyaline in KOH, of parallel hyphae; pileus trama with a thin gelatinous pellicle of narrow (2–3.4μ) hyphae, beneath it the hyphae rather compactly arranged and more or less pseudo-parenchymatous in tangential section, remainder filamentose and floccose, hyaline to pale brownish in KOH.

Subcespitose on boggy ground, Ann Arbor, Mich., Sept. 27, 1940 (15,476), and Oct. 1, 1942 (18,823-type).

Observations: This is the fungus previously referred to (Smith, 1942) as being close to *C. triumphans*. It is amply distinguished from that species and *C. luteo-armillatus* by its broadly ovate to subglobose spores. The colors of the pilei are much paler than in typical *triumphans*, and the pale bluish

PLATE 5.—*Cortinarius caesiellus* Smith, ×1.

gills furnish a field character by which it can be distinguished from *C. luteo-armillatus*. Both collections were found in the same boggy depression and in almost the same spot. Two species of Vaccinium, various oaks, one species of ash and scattered trees of shagbark hickory and ironwood make up the forest cover.

Cortinarius Riederi (Wienm.) Fr. is said to have tawny fibrils on the stipe. Ricken, however, placed this species in the group in which no universal veil is present and gave the spore size as 15–17×8–10μ. Cooke's figure of *C. Riederi* depicts a fungus with the stature but not the colors of *C. caesiellus*, and no universal veil remnants are shown.

C. decoloratus Fr. sensu Kauffman is identical with *C. caesiellus*. However the name *decoloratus* cannot be used legitimately for a species with a universal veil resembling that of *C. triumphans*. Kauffman left only one collection of four small fruiting bodies, and from this it is apparent that his acquaintance with the species was limited. *C. albidipes* Pk. is identical with *C. caesiellus* in all characters except the presence of the universal veil. Peck's figures clearly show, and the description clearly emphasizes the white zoneless stipe. The only colored zone mentioned is the one formed by the spores becoming lodged in the fibrils left by the broken cortina. It is possible that *C. decoloratus* Fr. and *C. albidus* Pk. are synonyms. However, there appears to be some difference of opinion in regard to the spore size of the Friesian species.

Cortinarius corrugis sp. nov.

Pileus 6–12 cm. latus, obtusus demum late convexus vel subumbonatus, glutinosus, demum corrugatus, laete incarnato-cinnamomeus vel subtestaceus; lamellae pallide luteae demum alutaceae, confertae, angustae; stipes 6–9 cm. longus, 1.5–2 cm. crassus, aequalis, pallidus demum sordide brunneus; sporae 7–9 (10)×3.5–4.5μ, laevae.—Specimen typicum A. H. Smith n. 16,842, legit prope Anderson Lookout, Baker National Forest, Wash., Sept. 11, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 6–12 cm. broad, obtuse with an incurved margin when young, becoming broadly convex or subumbonate in age, some merely remaining obtusely subcampanulate, surface glutinous when wet, glabrous or with scattered fibrillose patches along the margin, smooth at first but soon radially wrinkled to more or less corrugated, color "orange-cinnamon" on disc, "light pinkish cinnamon" toward the margin (bright to pale cinnamon), when water-soaked nearly "Verona brown" (dull somewhat vinaceous brown) not hygrophanous; flesh thick, firm, pallid (tilleul buff) but soon sordid brown around the wormholes, odor and taste none; lamellae "pinkish buff" (buff color) becoming "clay color" (pale yellow-brown) close to crowded (130–138 reach the stipe, 2–3 tiers of lamellulae, adnexed, relatively narrow (5–6 mm.), equal in width, very thin; stipe 6–9 cm. long,

1.5–2 cm. thick, solid and fibrous within, pallid brownish, equal, in age dark sordid brown at the base or over all, coated with a thin covering of pallid appressed fibrils, apex silky and pallid to brownish.

Spores 7–9 (10)×3.5–4.5μ, appearing smooth under ordinary magnifications but under oil immersion lens very finely punctate, narrow and inequilateral, pale tawny under the microscope; basidia four-spored; gill trama parallel, hyaline in KOH; pileus trama with a thick gelatinous pellicle, beneath it a pseudoparenchymatous layer of greatly enlarged cells (as seen in a section tangential to pileus) with rusty brown walls, the remainder floccose and nearly hyaline.

Subcespitose under conifers, elev. 4,000 ft., Ermine Creek Trail, below Anderson Lookout, Baker Lake, Wash., Sept. 11, 1941 (16,842-type).

Observations: Many of the specimens had a viscid zone at the base of the stipe, but I could not determine for certain whether the gluten represented the remains of a gelatinous veil or whether it had dripped from the pileus. The specimens developed during very wet weather. No buttons with the veil intact were found. Because of the similarity of this species to *C. corruscans* sensu Kauffman it is place beside the latter in Phlegmacium. Kauffman described the spores of *C. corruscans* as smooth, but an examination of all the carpophores in his Tennessee collection reveals that the spores are slightly wrinkled as in most Cortinarii. The spores of *C. corrugis* appear almost smooth even under an oil immersion lense. However, if one focuses on the surface of the spore, minute depressions can be observed in the spore wall. When mounts of both of these species are compared under the microscope the difference is very striking.

C. vespertinus Fr. is said to have spores 4–5×3–4μ and more yellowish rather than cinnamon colors. *C. liratus* Fr. appears to be rather close but little information about it is available. In my collection of *C. corrugis* the stipe was solid and homogeneous, the pileus not hygrophanous, and the surface of the stipe brunnescent at least at the base. These differences should distinguish it from *C. liratus*.

Cortinarius mutabilis sp. nov.

Plate 6

Pileus 4–8 cm. latus, convexus demum late convexus vel planus, glaber, viscidus, sordide violaceus; caro tactu purpurascens; lamellae violaceae, latae, confertae, confrictis purpureo-maculatae; stipes clavatus, 6–8 cm. longus, 10–15 mm. crassus, farctus, pallide lilacinus, tactu purpurascens; sporae 7–9×4.5–5μ.—Specimen typicum A. H. Smith n. 17,451, legit prope Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 4–8 cm. broad, convex with an inrolled margin, becoming plane or broadly umbonate, margin remaining incurved for a long time, glabrous

or nearly so, the margin often fringed from remains of the veil, surface glutinous and somewhat streaked beneath the gluten, color "dark plumbago gray" to "light plumbago gray" over all (dull violet-gray with a vinaceous tint); flesh thick and soft, more or less concolorous with the surface but soon pallid, odor and taste not distinctive, when cut or bruised changing slowly to near "aconite violet" (violaceous purple); lamellae concolorous with pileus when young, in age pale cinnamon brown from the spores but with a persistent violaceous cast, adnexed, broad (1 cm. ±), 64± reach the stipe, 2 tiers of lamellulae, close, changing to "purplish lilac" when bruised or finally concolorous with the flesh of the stipe, edges even; stipe clavate, 6–8 cm. long, 10–15 mm. thick at apex, 2–3 cm. at base, stuffed, pale lilac within and staining bright purple when cut or bruised, surface concolor with the cap or a brighter lilac, fibrillose with the pallid veil remnants, staining purplish when handled.

Spores 7–9×4.5–5μ, ellipsoid, faintly tuberculate, pale rusty brown under the microscope; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama regular or nearly so; pileus trama homogeneous beneath a thick gelatinous pellicle.

Gregarious under conifers, pine, Douglas fir and mountain hemlock Olympic Hot Springs, Sept. 30, 1941 (17,451-type); Oct. 2, (17,494); Oct. 8 (17,696); and Oct. 11, 1941, Stuntz and Smith no. 17,772.

Observations: Because of the similarity in spore size, color and color change, I was at first inclined to regard this species as a form of *C. occidentalis* Smith. A careful study of developmental stages, however, showed that it was a typical Phlegmacium and hence it must be regarded as a distinct species because of the difference in the manner of its development. Abundant young stages were found on four occasions, and large quantities of material were observed in the field. It was encountered on nearly all collecting trips to Olympic Hot Springs from late September to late October. In Phlegmacium it appears to be related to *C. porphyropus*, but differs in spore size and in the color of the pileus. *C. euchrous* Henry is somewhat similarly colored, but is said to have an aggreeable fruity odor and lacks the color change of *C. mutabilis*. Two collections, one from a sphagnum bog on Mt. Baker, Wash. (16,717) and one at the edge of a bog, Lake Angeles, Olympic Mts., Wash. (16,972) that may belong in *C. euchrous* were found in 1941. However, the stipes did not become yellowish in the lower half and the odor though pungent was slightly disagreeable and was noticeable only when the flesh was cut or broken. No cheilocystidia were observed. This form needs further study.

Cortinarius subfoetidus sp. nov.

Pileus (3) 4–10 cm. latus, obtusus dein planus, glutinosus, laete lilacinus demum pallidus; odor graveolens; lamellae lilacinae demum cinnamomeae,

PLATE 6.—*Cortinarius mutabilis* Smith, ×1.

confertae, latae, subdecurrentes; stipes 5–8 cm. longus, 10–20 mm. crassus aequalis, solidus, lilacinus dein pallidus, fibrillosus; sporae 7–9(10)×5–5.5μ.—Specimen typicum A. H. Smith n. 17778, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941; in Herb. Univ. of Mich. conservatum.

Pileus (3) 4–10 cm. broad, obtusely umbonate to plane, in age the margin becoming lacerated, surface glutinous, appressed fibrillose beneath the gluten, "bluish lavender" to "light lavender violet" (lilac) over all at first, fading to buff or pallid ("pale pinkish buff" or "tilleul buff") on the disc, margin retaining its lilac color; flesh thick (2 cm. in dia.) "bluish lavender" or brighter at first but soon becoming pallid, not changing when cut, taste mild, odor very heavy-aromatic to subfoetid (somewhat sweetish and nauseous); lamellae concolorous with the pileus young, near "Sayal brown" at maturity, close, 2 tiers of lamellulae, moderately broad (5–8 mm.), broadest in the middle, adnexed to subdecurrent; stipe 5–8 cm. long, 10–20 mm. thick at the apex, equal and solid, flesh concolorous with pileus at first and quickly becoming pallid, surface with a "bluish lavender" fibrillose sheath terminating in a median lavender fibrillose zone, color of sheath fading soon and leaving only the colored zone, apex silky, fibrillose from pale lavender fibrils, when old whitish over all, not changing color when handled.

Spores subellipsoid to slightly inequilateral, 7–9 (10)×5–5.5μ, rusty brown in KOH, outer wall wrinkled; basidia four-spored; pleuro- and cheilocystidia not seen, gill trama hyaline and parallel; pileus trama homogeneous and hyaline beneath a somewhat differentiated pellicle of narrow subgelatinous hyphae, a delicate pinkish lilac tint diffused throughout the pellicle when the latter is revived in KOH.

Scattered under conifers, Mt. Angeles, Olympics, Wash., Oct. 7, 1941 (17,613); Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941, (17,778-type) Stuntz and Smith; same locality, Oct. 15 (Smith, 17,907).

Observations: The outstanding features of the species are the sickening-sweetish heavy aromatic odor, bright lilac colors of all parts, and the viscid pileus. The smaller spores, which rarely measure 10μ long, distinguish it from *C. balteato-cumatilis* Henry and its North American forms. Collection 17,438 (Olympic Hot Springs) of the latter had an odor like that of *C. pyriodorus*. Its spores measure 8–11×4.5–6μ. The stems were 10–12 cm. long, 2–4 cm. thick at the apex and 3–6 cm. at the base. The caps measured up to 30 cm. broad. The colors, however, were very similar to those of *C. subfoetidus* and the appearance of the dried specimens is also similar. Both are rather bright lilac at least near the margins of the pilei. *C. euchrous* Henry appears to be very similar to *C. subfoetidus* in many respects but has creamy white flesh and abundant cheilocystidia. It is described as having an agreeable fruity odor. *C. nemorosus* Henry differs in

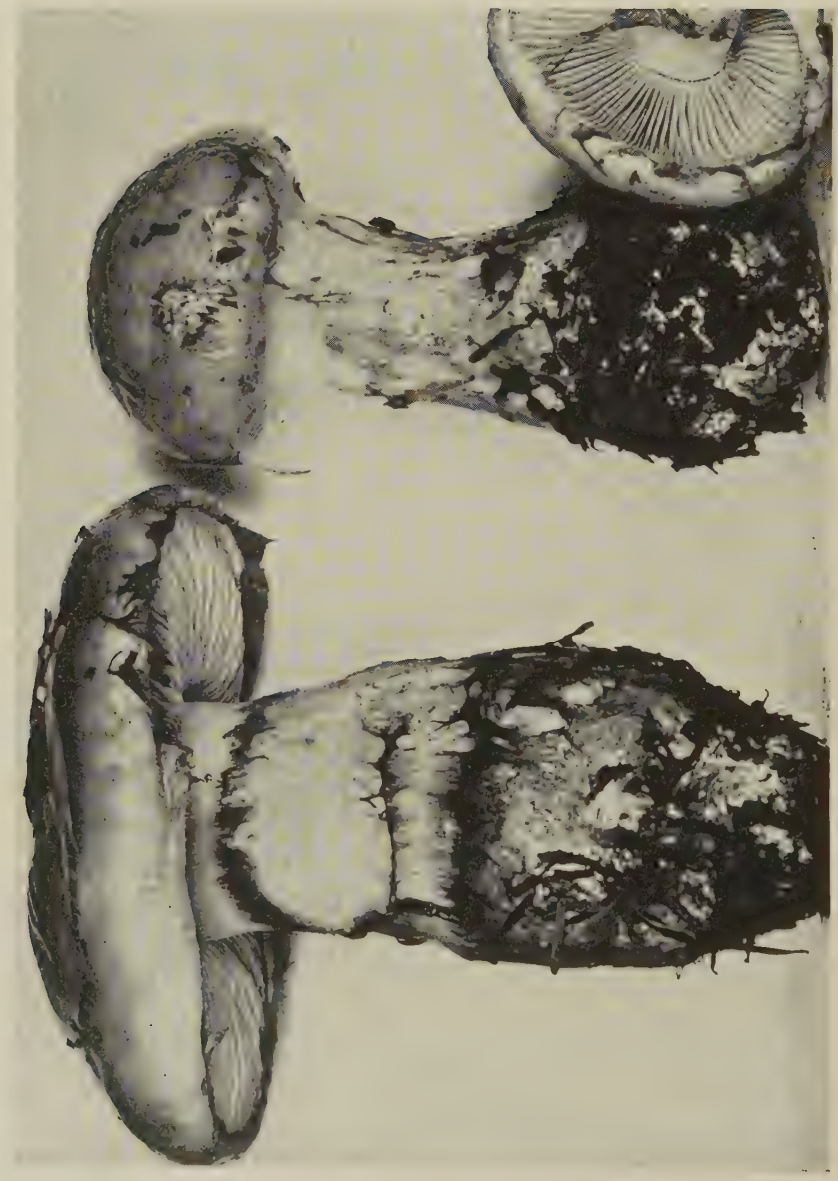

PLATE 7.—*Cortinarius superbus* Smith, ×1.

its much larger spores (13–14×6.5μ), bulbous and lutescent to brunnescent stipe, bitterish taste and fruity instead of a sickening, heavy, sweetish odor.

Cortinarius superbus sp. nov.

Plate 7

Pileus (4) 6–12 (15) cm. latus, convexus demum late convexus vel planus, glutinosus, fibrillosus, pallide olivaceo-luteus, testaceo-brunnescens; odor valde distinctus; lamellae subsulphureae dein fulvae, confertae, latae; stipes 6–9(15) cm. longus, sursum 1–2.5 cm. crassus, deorsum 3–4.5 cm., clavatus, valde fibrillosus, subsulphureus, deorsum testaceo-brunnescens; sporae 11–13×5.5–7.5μ.—Specimen typicum A. H. Smith n. 17,680, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941; in Herb. Univ. of Mich. conservatum.

Pileus (4) 6–12 (15) cm. broad, convex with an inrolled margin finally becoming broadly convex to plane, surface glutinous in wet weather, sometimes merely viscid after prolonged rain, the gluten often accumulating and drying on the disc in the form of spotlike scales and often dripping from the margin onto the base of the stipe, more or less fibrillose streaked beneath the gluten, pale yellowish when young ("cartridge buff") or with an olivaceous cast over all, soon becoming more or less vinaceous brown ("Mikado brown" to "Verona brown") or a brighter reddish brown over the disc, the margin usually remaining yellowish or olivaceous; flesh thick and firm (up to 2 cm. thick in the disc), tapered abruptly near the margin, pale yellow ("straw yellow" to "Barium yellow"), "Chartreuse yellow" in the apex of the stipe, soon becoming sordid brownish where cut or bruised (particularly in the base of the stipe), taste not distinctive, odor rather strong and very distinctive, reminding one somewhat of the odor of fresh green corn; lamellae "straw yellow" when young, gradually becoming rusty yellow-brown, close, 107 ± reach the stipe, 2 tiers of lamellulae, adnexed, broad (7–9–15 mm.), equal, horizontal, sometimes crisped, edges slightly uneven to serrate; stipe 6–9 (12) cm. long, 1–2.5 cm. thick at the apex, clavate, up to 4.5 cm. at the base, solid, yellow within but soon brownish when cut, surface densely fibrillose from the remnants of the copious yellow cortina, surface and fibrils more or less olive-yellow ("pale chalcedony yellow"), soon becoming dark sordid brown at the base or where handled and usually with an agglutinated dark basal zone of fibrils (apparently caused by gluten dripping from the cap or by a rudimentary gelatinous outer veil).

Spores 11–13×5.5–7.5μ, slightly roughened, somewhat almond-shaped, dark rusty brown under the microscope in KOH; basidia four-spored; cheilocystidia none; pleurocystidia absent but in revived mounts scattered basidia-like cells present having an amorphous reddish to purplish content

in KOH; gill trama more or less regular to interwoven; pileus trama slightly purplish in KOH, surface covered by a thick gelatinous pellicle.

Scattered to gregarious on steep mountain slopes, Olympic Hot Spings Olympic National Park, Wash., Sept. 30, 1941 (17,443); Oct. 2, (17,492); Storm King Mt., Oct. 5 (17,580); Mt. Angeles, Olympics, Wash., Oct. 7 (17,645); Olympic Hot Springs, Oct. 8 (17,680-type); Lost Creek, Ore., Oct. 30, 1941 (18,162).

Observations: It is difficult to decide the subgeneric position of this species. At times it appeared to be a Myxacium and at other times a Phlegmacium. The gelatinous sheath, if present, is very thin and present only on very young carpophores. It soon is evident only as a discolored somewhat varnished-appearing band around the clavate base of the stipe. In many instances this band appeared to be caused by gluten that had dripped from the pileus, but in many others it was distributed in such a manner as to be clearly the remains of a gelatinous sheath. At the time the type collection was made about six market baskets of specimens were collected and no definite subgeneric disposition could be arrived at. The gluten from the cap often drips onto the base of the stipe before the veil breaks and such buttons lead one to place the fungus in Myxacium. However, since the species appears to be closely related to *C. percomis* of Phlegmacium, it is referred to that subgenus.

The outstanding characters of this species are the color and color change of the flesh of the pileus and stipe, the massive stem, copious cortina and odor. It appears to be closest to *C. nanciensis* Maire and *C. percomis* Fr. *Phlegmacium russum* (Fr.) Ricken is also close, but Ricken's fungus can hardly be *C. russus* Fr. since the flesh of the latter is pallid at first, not sulphur yellow, and should have a very disagreeable taste. It is also doubtful if Ricken's fungus with is odor of *Tricholoma lascivum* and white base of its stipe can be referred to *C. superbus*. *C. nanciensis* differs in having a universal veil with grayish lilac to brownish lilac tints, and in lacking a characteristic odor. There is apparently a difference in size and also in the attachment of the lamellae, but these are more likely to be variable characters. Although the change in color of the pileus is suggestive of *C. orichalceus*, and dried specimens of the two are similar in color when first dried, they can be easily distinguished after standing for a time (several weeks to a month) in the presence of napthalene. Those of *C. orichalceus* become deep purplish whereas those of *C. superbus* retain their olive brown colors. *C. Friesii* Bres. & Schulz. apparently has a similar odor, but has totally different colors.

CORTINARIUS CLIDUCHUS Fr., Epicrisis Syst. Myc., p. 260. 1838.

Pileus (5) 7–14 cm. broad, obtuse to broadly convex, becoming plane or with a slightly depressed disc, margin at times somewhat elevated in age,

surface glutinous when wet, appearing fibrillose-streaked beneath the gluten, color dominantly "cinnamon-buff" over all at first, (yellowish), disc soon yellowish tawny ("ochraceous tawny"), in age sometimes more or less tawny over all; flesh very thick and firm in the disc, tapering abruptly toward the margin, pallid yellowish or when water-soaked with a greenish tint, odor none, taste mild; lamellae close, broad, shallowly adnexed or merely slightly depressed, becoming short decurrent, whitish to "pale pinkish buff" (yellowish) young, in age more or less "ochraceous tawny" intermediate stages sometimes nearly avellaneous, edges even or eroded; stipe 6–12 cm. long, 10–20 mm. thick at apex, clavate to nearly equal, solid but becoming hollow, pale watery yellowish within, surface whitish from a thin coating of appressed silky fibrils, glabrescent and yellowish in age, the cortina leaving a slight or rather distinct fibrillose zone.

Spores 9–11×5–6μ, slightly inequilateral to subalmond-shaped, roughened, rusty brown under the microscope; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama parallel to subparallel, hyaline in KOH; pileus trama homogeneous beneath a gelatinous pellicle, region next to the pellicle tawny in KOH.

Gregarious to subcespitose under alder along the trail to Lake Angeles, Mt. Angeles, Olympic Mts., Wash., Sept. 19, 1941 (16,971).

Observations: Kauffman (1932) apparently described material of this species from Washington under the name *C. saginus* Fr. Among his collections only one so labelled has been located. It has dried a dark mineral red and appears to belong in *C. orichalceus* instead. It was collected at Lake Cushman, also in the Olympics, in 1915, and was one of several specimens collected at different intervals. Apparently it was not used in making up his notes, however, since there is nothing in his published account of *C. saginus* to indicate *C. orichalceus*. The additional specimens must have been lost or spoiled in drying. Henry (1939) has placed a species obviously very closely related to the one Kauffman described but with spores 8–9×6.5–8μ under the name *C. saginus*. He pointed out that Ricken's concept of *C. saginus* was not consistent with the Friesian descriptions and that Rea (1922) had translated the Friesian description and added Ricken's spore measurements thus creating a confused concept. Lange and Bresadola did not include *C. saginus* in their Icones. Henry accepts Cooke's illustration although R. Maire, Quélet, and Rea believed the latter represents *C. triumphans* (see Pearson, 1935). My material of *C. triumphans* and *C. cliduchus* does not compare well with Cooke's plate of *C. saginus*. In order to stabilize the nomenclature, Henry's concept of *C. saginus* rather than Kauffman's is recognized, and the American collections are placed in *C. cliduchus*. *C. cliduchus*, sensu Konrad and Maublanc, however, is characterized by yellowish bands over the lower part of the stipe. Such bands were not present in my material and are not indicated in

the Friesian descriptions. *Phlegmacium cliduchus* of Ricken, characterized by a strong odor and yellow fibrillose bands on the stipe has been referred to *C. cephalixus* Secr. by Henry (1936). My material apparently differs slightly from the Friesian descriptions in having paler gills and in growing under alder in the mountains instead of in beech woods.

CORTINARIUS CRYSTALLINUS Fr. sensu Bresadola and Lange.

Pileus 3–5 cm. broad, obtuse with an inrolled margin, becoming broadly umbonate to nearly plane, surface glabrous and glutinous (all had been exposed to continuous rain for several days), "tilleul buff" (whitish) with "pinkish buff" to "cinnamon-buff" watery streaks or spots, entire disc gradually becoming "cinnamon-buff" (buff color); flesh thick (5–8 mm. in the disc), tapered abruptly, watery punctate, "pinkish buff" or more yellowish and very pale buff in age, very soft and fragile, taste of pellicle very bitter (like *Mycena fellea*), odor not distinctive; lamellae "tilleul buff" (pallid) young, becoming "pinkish buff" (pale buff) at maturity, very pale at all stages and drying more or less "ochraceous tawny," narrow (up to 5 mm.), bluntly adnate, close, 81–86 reach the stipe, 2–3 tiers of lamellulae, edges slightly wavy; stipe equal to slightly clavate, 4–8 cm. long, 9–15 mm. at apex, 15–20 mm. thick at base, tapered below the enlarged portion to a rootlike projection, solid but becoming hollow, pale buff within ("pinkish buff"), surface whitish and covered by a thin coating of appressed dry fibrils, soon glabrescent and appearing watery and more or less concolorous with the pileus.

Spores 5.5–7 (8)×3.5–4μ, nearly ellipsoid, slightly roughened, pale yellowish in KOH; basidia four-spored; cheilo- and pleurocystidia not differentiated; gill trama hyaline in KOH, of parallel hyphae; pileus trama homogeneous or nearly so beneath a gelatinous pellicle, floccose tramal body slightly yellowish in KOH next to the gelatinous layer.

Scattered to gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941, Stuntz and Smith 17,779.

Observations: An outstanding species because of the very bitter pellicle, very small spores and pallid to pale yellow-buff color. Henry (1936) has described a very similar species under the name *C. causticus*. It differs from the Olympic material chiefly in having a slight gelatinous veil on the stipe at first. Lange (1938) has described *C. crystallinus* as having a dry stipe, but otherwise there are few if any characters to distinguish between the two. Lange placed *C. crystallinus* in Myxacium because of its relationship to *C. vibratilis* and the other bitter species of Myxacium. His accounts of both *C. crystallinus* and *C. emollitus* appear to apply to the same fungus. It may well be that *C. causticus* should be included here also. However, in view of the difficulty encountered in deciding whether a species belonged in Phlegmacium or Myxacium in certain other cases, and the

lack of any doubt in this species, I have used the name *crystallinus* which is consistent with the characters of the fungus.

Peck reported *C. crystallinus* for New York in 1878 but I have not examined his specimens. Kauffman (1932) did not recognize the species as occurring in North America but apparently did not account for Peck's report.

CORTINARIUS LATUS Fr., Epicrisis Syst. Myc., p. 260. 1836.

Pileus 5–10 cm. broad, very broadly convex with an inrolled margin, expanding to plane or with a low broad umbo, surface very glutinous when wet but soon dry, glabrous or more or less appressed-fibrillose beneath the gluten, color evenly "light pinkish cinnamon" to "pinkish cinnamon" young (pale cinnamon with a pinkish tinge), becoming "pinkish buff" (pale buff) on the margin and pale cinnamon-tan on the disc, always with a clean fresh appearance, occasionally the margin with a faint lilac tinge; flesh thick, white, firm (1.5 cm. in umbo), tapered abruptly, unchanging when cut or bruised, odor and taste mild; lamellae close to crowded, rather narrow (5–6 mm.), equal ±, adnate but becoming slightly adnexed, very pale buff or pallid (nearly white when young), sometimes developing a faint lilac tint before becoming pale cinnamon, finally dull cinnamon ("Sayal brown"), edges even; stipe 7–10 cm. long, 10–15 mm. thick, usually with an abrupt flanged bulb but sometimes clavate and bulb-margin obsolete, nearly equal in age, becoming hollow, white throughout and unchanging, cortina scant to copious, lower portion of stipe at first white fibrillose from its remains, glabrescent, with occasional patches of gluten from the pileus but lacking a gelatinous universal veil.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941 (17,506); Oct. 8 (17,683 and 17,711); Oct. 11 (17,773).

Observations: In collection no. 17,711 the pilei developed a lilac tinge in the margin, and the gills, though white at first, also became faintly lilac in partly expanded buttons. The development of this tint appeared to be secondary. Because of the typically pallid gills and pale cinnamon cap the species appears closely related to *C. multiformis* and *C. Bouderi*. Since usuage has clearly established the name *C. latus* for a Phlegmacium, there is no need to discard it simply because the plant was not placed in that subgenus in Systema vol. 1. My collections appear to represent the species as Fries described it in his later works. It is doubtful if Ricken's *Phleg. latum* with its somewhat yellowish flesh and stipe is typical. The clear white flesh was an outstanding character of my material. Bresadola's (1929) illustration is excellent. He described the pileus as subviscid. My collections differed in being very glutinous but the gluten was thin and soon dried out to give the usual shiny appearance to the pilei.

PLATE 8.—*Cortinarius fragrans* Smith, ×1.

INOLOMA and DERMOCYBE

Cortinarius fragrans sp. nov.

Plate 8

Pileus (2) 3–6 (9) cm. latus, campanulatus, siccus, fibrillosus, pallide lilacino-vinaceus demum ligno-brunneus; odor fragrans; lamellae subdistantes, latae, adnatae vel subdistantes, pallide lilacinae dein cinnamomeae; stipes 5–10 cm. longus, (4) 6–8 (11) mm. crassus, subaequalis, sursum lilacinus, deorsum lilacino-avellaneus; fibrillosus vel fibrilloso-zonatus; sporae 8–10×4–5.5μ.—Specimen typicum A. H. Smith n. 17,713, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941; in Herb. Univ. of Mich. conservatum.

Pileus (2) 3–6 (9) cm. broad, obtusely conic with an incurved margin, becoming campanulate to subplane with a low obtuse conic umbo, surface dry and innately fibrillose, pallid when young but tinged lilac ("pale vinaceous fawn"), slowly becoming darker, some tinged "light vinaceous cinnamon" toward the margin and more or less wood brown over the disc, sometimes with more of a vinaceous tinge; flesh thin, tapered abruptly away from the disc, pallid but tinged lilac when young, in age lilac-buff or nearly white, taste mild, odor very distinctive, fruity (as in *C. pyriodorus*); lamellae subdistant, 33± reach the stipe, 2 tiers of lamellulae, broad (5 mm. ±), equal and horizontal in age, adnate and developing a short decurrent tooth, seceding in some, pale dull lilac to "light vinaceous cinnamon" (pale pinkish cinnamon with barely a tinge of lilac) young, becoming dull cinnamon at maturity ("Sayal brown" or darker); stipe 5–10 cm. long, (4) 6–8 (11) mm. thick, equal or merely subbulbous at the base, stuffed, the pith pallid, cortex "lavender" at least above but throughout in vigorous specimens, surface scurfy near the apex, very ragged-fibrillose below from veil remnants, usually more or less zoned, veil remnants lilac fading to pallid, bright lavender above, duller toward the pallid base which finally becomes slightly brownish ("avellaneous" in the base in age).

Spores 8–10×4–5.5μ, ellipsoid, roughened, dark dull rusty brown in KOH; basidia four-spored, pale sordid yellowish brown in KOH; pleuro- and cheilocystidia not found; gill trama regular, pallid; pileus trama with slightly larger cells near the surface, dull brown in KOH near or at the surface, tramal body nearly hyaline.

Scattered to gregarious, under conifers, Olympic Hot Springs, O'ympic National Park, Wash., Sept. 30, 1941 (17,454); Oct. 2 (17,552); Oct. 8 (17,713-type); Oct. 15 (17,900) and Mt. Angeles, Olympics, Wash., Oct. 4 (17,558), and Oct. 7 (17,635), 1941.

Observations: This is a small to medium sized species related to *C. pyriodorus* Kauffman by its odor and colors but it differs in its duller lilac tints, smaller size, slender and nearly equal stipe, and more distant lamel-

lae. It is close to *C. myrtillinus* in some respects but possesses a copious universal veil and has somewhat different colors. *C. myrtillinus* is not described as having a characteristic fruity odor. *C. subtabularis* is quite similar but lacks a universal veil, has an abruptly bulbous stipe, close gills and has no characteristic odor. *C. fragrans* is a common species in the vicinity of Olympic Hot Springs and very constant in the characters emphasized.

CORTINARIUS TURGIDUS Fr. Epicrisis Syst. Myc., p. 278. 1836.

Pileus 3–6 cm. broad, very broadly convex when young, becoming plane or with a low obtuse umbo, the margin usually decurved but finally spreading or raised up slightly, surface dry and appressed fibrillose, nearly pallid to "pinkish buff" (pale buff) young, becoming "cinnamon-buff" to "clay color" (pale alutaceous), somewhat streaked in age; flesh more or less watery-punctate and pallid, watery avellaneous along the gills, thick (6 mm. ±) at the stipe, tapered evenly, soft and fragile, odor faintly fragrant, taste mild; lamellae pallid to very pale brownish when young, soon yellowish ("warm buff") and finally pale ochraceous tawny, broadly adnate, becoming short decurrent, broad (8 mm. ±), close, 67 ± reach the stipe, 2 tiers of lamellulae, edges becoming slightly uneven; stipe clavate, 6–10 cm. long, 8–12 mm. at apex, bulb 1.5–3 cm. thick, solid and pallid within, soft and fragile, surface concolorous with the pileus and thinly fibrillose, somewhat glabrescent, becoming a brighter pale yellowish brown in age.

Spores 8–9.5 (10) × 5–6μ, ellipsoid or nearly so, roughened, tawny in KOH under the microscope; pleuro- and cheilocystidia none; gill trama regular, hyaline in KOH; pileus trama with a thin pellicle of slender nongelatinous hyphae, beneath this a region of enlarged cells with tawny walls (in KOH), the remainder hyaline and floccose.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941 (17,458); Oct. 15 (17,902).

Observations: When dried the specimens are a pale rather bright cinnamon. The relationship to *C. argentatus* is quite striking, but lilac colors, of course, are not present. *C. turgidus* is practically dull white and silky-shining at first, but gradually assumes yellowish and finally alutaceous hues as the carpophores age. *C. argutus* differs in having an almost root-like projection below the bulb, subdistant gills and large spores, but appears to be similar in most other characters. The cuticle of the stipe in *C. turgidus* is somewhat cartilaginous but in my collections it did not become rimose. The latter is a character not likely to develop well in very wet weather.

CORTINARIUS ORELLANUS Fr., Epicrisis Syst. Myc., p. 288. 1836.

Pileus 2–4.5 cm. broad, obtuse with an incurved margin, becoming

obtusely campanulate or nearly plane with an obtuse umbo, surface innately fibrillose to slightly fibrillose-furfuraceous, margin opaque, disc "chestnut brown," "russet" to "tawny" toward the margin, near "walnut brown" over all in age (dark rusty brown to chestnut brown at first, dull testaceous in age), not hygrophanous, flesh thin, near chestnut brown moist, odor none, taste mild; lamellae "tawny" but soon "ochraceous tawny" (dark tawny young, more yellowish at maturity), sinuate, nearly subdistant, 35± reach the stipe, 2 tiers of lamellulae, broad (4–5 mm.), becoming ventricose, edges uneven, intervenose; stipe 3.5–5 cm. long, 4–7 mm. thick, hollow or becoming so, equal, thinly fibrillose toward the base with pallid fibrils from the remains of the cortina, when young pallid buff over all from veil fibrils (yellowish), becoming tawny or sordid tawny in the base, paler brown and silky toward the apex.

Spores 9–11×5–6μ, narrowly subellipsoid, roughened, pale tawny in KOH under the microscope; pleuro- and cheilocystidia not seen; gill trama parallel, pale tawny in KOH; pileus trama with a surface layer several cells thick of slightly enlarged hyphae with yellowish walls (in KOH).

Gregarious on moss beds in an alpine meadow, Anderson Lookout, Baker National Forest, Wash., Sept. 13, 1941 (16,907).

Observations: The illustrations of this species by Konrad and Maublanc (1924–32) picture my specimens exceptionally well; the smaller figures in particular. At first I was inclined to place my material in *C. croceoconus* Fr. Kauffman (1918) gave a description of material he collected in Sweden, but his specimens could not be located for a critical comparison. The only collection among his Cortinarii bearing this name is the one he (1921) reported for Colorado. His notes on the label of the latter state that the fruiting body was overheated in drying. Since Kauffman did not recognize *C. croceoconus* in his monograph (1932) it is assumed that he later entertained some doubt over the identity of his Colorado collection. Fries has emphasized that *C. croceoconus* has an acute persistent umbo and that the cap is not squamulose. These two characters prevent my no. 16,907 from being identified as that species and seem to place it in *C. orellanus*. *C. subcinnamomeus* Cleland[2] (Smith, 1935) has somewhat similar spores but the two species are quite different in other respects, particularly in the much more pronounced olive colors of the latter. Its scales are caused by the cuticle and upper layer of the flesh together becoming broken up whereas in *C. orellanus* the very minute scales are caused by the recurved or upright threads of the cuticle and are present from the beginning instead of developing at maturity or later.

[2] Since the name *Cortinarius subcinnamomeus* Karsten antedates that of Cleland, the name **Cortinarius Clelandii** nom. nov. is given to the Australian species.

CORTINARIUS ULIGINOSUS Berk. sensu Lange, Flora Agaricina Danica 3: 34. Pl. 95, fig. A. 1938.

Pileus 1.5–5 cm. broad, obtuse or obtusely conic when young, the margin incurved, becoming campanulate, obtusely umbonate or nearly plane, the margin spreading or remaining decurved, surface dry and appressed fibrillose, sometimes appearing slightly furfuraceous but not scaly, color "vinaceous rufous" over all (bright rusty red) or the disc "burnt Sienna" (a bit more orange), "Kaiser brown" at times, gradually becoming paler especially along the margin ("apricot buff") and occasionally splashed sordid greenish; flesh thin, rather pliant, "aniline yellow" (rich yellow with an olive cast) and in age distinctly greenish brown, odor of radish, taste very strongly raphanoid but also having a bitter aftertaste; lamellae "aniline yellow" young, finally "ochraceous tawny" but frequently remaining "ochraceous buff" (dull yellowish buff instead of pale tawny), moderately close, 26–37 reach the stipe, 2–3 tiers of lamellulae, moderately broad (4–5 mm. ±), depressed adnate to sinuate, seceding, edges slightly eroded; stipe 4–9 cm. long, 3–6 mm. thick, equal, hollow, cortex watery orange, interior tinged yellowish green, surface with "English red" fibrils on a "Salmon orange" ground color, in age fading to straw yellow near the apex and sordid orange toward the base, veil scanty and "Kaiser brown" fading to "orange-buff."

Spores ellipsoid, 7–9 (10)×4–5μ, slightly tuberculate; basidia four-spored; pleurocystidia present only as metallic-appearing basidia-like bodies that are greenish in fresh material and brownish in KOH; cheilocystidia saccate, 26–30×9–12μ, numerous to scattered, hyaline; gill trama regular, with pockets of amorphous pigment which are greenish in fresh material but reddish when revived in KOH; pileus trama homogeneous beneath a surface layer of hyphae filled with cinnabar red contents.

Gregarious on soil under alder and willow on marshy ground, Joyce, Washington (Olympic Peninsula), July 5, 1939 (14,784), and Park Creek, Mt. Baker, Washington, in beds of Polytrichum on poorly drained ground Sept. 10, 1941 (16,807 and 16,808).

Observations: After collecting the carpophores from Joyce, I visited the type locality of *Inocybe ferruginosa* but failed to get any specimens. The type locality was visited again in 1941 with the same result. These two species have almost exactly the same appearance, and their microscopic characters are also practically identical. They differ in the spermatic odor of the Inocybe, its nauseating taste and whitish flesh when young. Since the latter has spores with a somewhat wrinkled wall it appears more logical to place it in Cortinarius in spite of its odor and Inocybe-like stature. Because of its resemblance to *Cortinarius uliginosus* in all basic characters, it appears best to make it a variety of that species, and the new name C.

uliginosus var. **nauseosus** nom. nov. is proposed. The name *ferruginosus* is inappropriate as a varietal name (syn. *Inocybe ferruginosa* Smith, Papers Mich. Acad., Sci., Arts and Letters, **24**: 93, Pl. II, fig. 3; Pl. III, figs. 15–16. 1939).

Peck reported *C. uliginosus* from New York, but I have not made a critical study of his specimens. Kauffman did not recognize Peck's report in either his Agaricaceae of Michigan or in the North American Flora.

TELAMONIA

Cortinarius angelesianus sp. nov.

Pileus 1–2.5 cm. latus, conicus vel campanulatus, sordide alutaceo-squamulosus, umbrinus, hygrophanus, demum avellaneus; lamellae obscure ferruginae dein testaceae, confertae vel subdistantes, latae, adnatae vel subdecurrentes; stipes 3–6 cm. longus, 4–6 mm. crassus, aequalis vel deorsum attenuatus, subfulvus, deorsum fuscus; fibrillosus; sporae 7–8 × 4–5μ.—Specimen typicum A. H. Smith n. 17,629, legit prope Mt. Angeles, Olympic Mts., Wash., Oct. 7, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1–2.5 cm. broad, conic when young, the margin incurved against the gills, becoming conic-campanulate or plane with a small umbo, surface covered from disc to margin with a dense coating of "snuff brown" (dull yellowish brown) fibrils which become aggregated into numerous small recurved fibrillose scales, not glabrescent, moist and hygrophanous beneath the fibrillose coating, ground color "bister" (dark umber brown) but this generally obscured by the scales, fading very slowly to dull dark avellaneous; flesh thick on the disc, abruptly tapered and thin over remainder of pileus, nearly "russet" (deep reddish brown) moist, dull grayish brown faded, odor and taste not distinctive; lamellae "russet" to "cinnamon-brown" young, remaining so or becoming dull cocoa-brown in age (very dark at all times) moderately close to subdistant, 23–30 reach the stipe, 2–3 tiers of lamellulae, moderately broad, adnate and with a slight decurrent tooth, edges even but a bit wavy; stipe 3–6 cm. long, 4–6 mm. at apex, equal or tapered to a pointed base, solid, cinnamon-brown within, darker (near bister) at the base, surface covered with a thin coating of appressed fibrils concolorous with those on the pileus, cortina buff colored and very scanty, universal veil remnants lacking or as small inconspicuous patches of brownish fibrils around the base, these soon evanescent.

Spores 7–8 × 4–5μ, broadly subellipsoid, slightly roughened, pale tawny under the microscope; basidia four-spored, the walls very slightly colored pale testaceous (in KOH) and many that are more or less collapsed dark testaceous in color; gill trama subregular, the hyphae with an abundant incrusting pigment causing the trama to be dark brown with a vinaceous or testaceous tinge when revived in KOH (the color very distinctive);

pileus trama more or less homogeneous and colored like the gill trama (very dark), the surface with fascicles of fibrils projecting to form the scales.

Scattered to singly on very decayed conifer wood, Olympic Hot Springs, Olympic National Park, Wash., Sept. 22, 1941 (18,822); Mt. Angeles, Olympics, Wash., Sept. 26 (17,292); Sept. 28 (17,379) and Oct. 7, 1941 (17,629-type).

Observations: This species has much the stature of small specimens of *C. flexipes* and the scales on the pileus also remind one of that species. It differs, of course, in the color of the scales and lack of any violaceous hues. The gills of dried specimens are dull chocolate color and aid in distinguishing herbarium specimens. It is difficult to be sure of the subgeneric position of this species. The lack of any appreciable veil remnants on the stipe at maturity may cause some to search for it in Hydrocybe near *C. acutus*. It appears to be most closely related to *C. helvelloides*, however. The latter is distinguished by larger spores and violaceous gills. *C. Cookei* Quél. appears to be practically identical with *C. helvelloides*, but may possibly be distinguished by its smaller spores. *C. lacorum* Smith is a true Dermocybe. Lange has reduced it to synonymy with *C. helvelloides*, but the question needs further study.

C. angelesianus, in spite of its brown universal veil does not appear to be even closely related to *C. psammocephalus* and its forms. The reaction of the gill and pileus trama in KOH distinguishes dried material from the latter group, and the very dark rusty gills and generally darker duller colors separate fresh specimens. *C. flavornatus* Singer can be readily distinguished by its much larger spores (7–11 × 7–8μ) and apparently by the brighter olive to yellow colors of the fresh pilei.

Cortinarius boulderensis sp. nov.

Plate 9

Pileus 2–4 cm. latus, conicus dein campanulatus, striatus, subtestaceus, ad marginem subviolaceus, demum cinnamomeus; lamellae griseo-lilacinae dein cinnamomeae, confertae, latae; stipes 5–8 cm. longus, 4–7 mm. crassus, sursum subpurpureus, deorsum pallide brunneus et vinaceo-fibrillosus vel zonatus; sporae 7–8 (9) × 4–5.5μ.—Specimen typicum A. H. Smith n. 17,461, legit prope Olympic Hot Springs (Boulder Creek), Olympic National Park, Wash., Sept. 30, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 2–4 cm. broad, obtusely conic and with an almost straight margin when young, becoming campanulate to plane or retaining a low obtusely conic umbo, surface moist and glabrous but appearing silky when faded, color "bone brown" to "warm sepia" or with a violaceous brown cast at first (dark dull reddish brown to chocolate brown), becoming "Rood's brown" (deep vinaceous brown), and faintly striatulate on the margin,

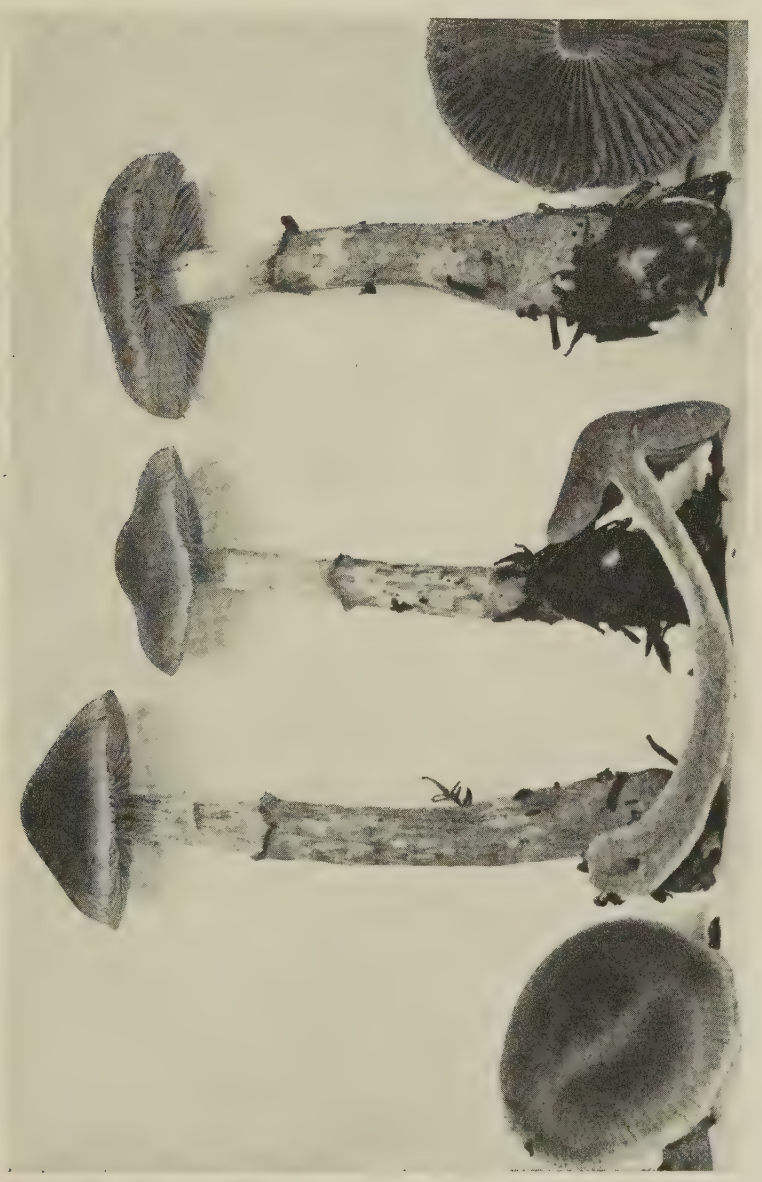

PLATE 9.—*Cortinarius boulderensis* Smith, ×1.

hygrophanous, fading to "Sayal brown" (dark cinnamon); the margin sometimes plicate-crenate in age; flesh thin and fragile, concolor with surface and fading to sordid vinaceous buff, odor and taste not distinctive; lamellae "light vinaceous drab" when young, becoming "Sayal brown" in age (grayish lilac at first, dull cinnamon in age), moderately close, 39–44 reach the stipe, 2 tiers of lamellulae, broad (5 mm.±), adnate with a decurrent tooth, edges slightly uneven; stipe 5–8 cm. long, 4–7 mm. thick at the apex, base slightly bulbous, hollow and fragile, cortex "pale purple-drab" above, pallid brownish toward the base, surface "pale purple-drab" at the apex and appressed silky, brownish below, with a median "vinaceous fawn" (testaceous) annular band from universal veil remnants, usually with scattered patches of vinaceous fibrils lower down, occasionally sheathed with testaceous fibrils over the lower third.

Spores 7–8 (9) ×4–5.5μ, ellipsoid, slightly roughened, rusty brown under the microscope; basidia four-spored, not purplish when revived in KOH; gill trama regular to subregular, hyaline to pale brownish in KOH; pileus trama homogeneous, dull brownish in KOH.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941 (17,461-type).

Observations: This is a very characteristic Cortinarius of the *C. armillatus-C. haematochelis* series but differing from both in the grayish lilac gills and dull violet color of the apex of the stipe. It is smaller than either of the above. From descriptions it is most likely to be confused with *C. paragaudis* (Smith, 1939). Dried material of *C. paragaudis* has "deep livid brown" (almost haematite red) mycelium at the base of the stipe, and the dried specimens are tinged strongly with the same color. When mounted in KOH the gill and cap trama becomes deep purple and this pigment diffuses throughout the mount. No such changes take place in *C. boulderensis*. There is, of course, a corresponding difference in fresh specimens. Those of the latter species are pallid brownish in the base of the stipe and in *C. paragaudis* the color is deep purplish. From *C. subtestaceus* Smith *C. boulderensis* differs in its smaller spores, glabrous pileus, smaller size, habitat and color of both the young gills and apex of the stipe. *C. boulderensis* differs from *C. spilomeus* in its moist translucent-striate pileus and narrower spores (6–9×6–7μ in *C. spilomeus* as compared with 7–9×4–5.5μ). However, it is very likely closely related to *C. spilomeus*, in fact it may eventually be desirable to group *C. spilomeus*, *C. boulderensis*, *C. armillatus*, *C. haematochelis* and *C. subtestaceus* together in a subgroup or stirps of Telamonia.

Cortinarius mucicola sp. nov.

Pileus 1.5–3.5 cm. latus, conicus dein umbonatus, cinnamomeo-brunneus, striatus, dein avellaneus, glaber dein sericeus; lamellae lilacinae, dein

cinnamomeae, latae, subventricosae, confertae; stipes 5–6 cm. longus, 3–6 mm. crassus, aequalis, deorsum albo-fibrillosus vel zonatus; sporae 7–9×4–5μ.—Specimen typicum A. H. Smith n. 17,455, legit prope Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1.5–3.5 cm broad, obtusely conic with an incurved margin young, becoming plane with a conic or obtuse umbo in age, the margin spreading and often wavy, surface glabrous, moist, hygrophanous, "cinnamon-brown" or slightly paler moist, either evenly colored or the umbo darker, translucent striate along the margin, fading to nearly avellaneous on the margin and then appearing somewhat appressed fibrillose, in age appearing faintly fibrillose over all; flesh 4–5 mm. in the umbo but abruptly thinner toward the margin, watery "snuff brown" moist, dull dirty buff color faded, odor and taste not distinctive; lamellae "dull lavender" (pale lavender) when young but quickly changing to pale or dark cinnamon-brown with no trace of lavender remaining, close, 34–37 reach the stipe, 1–2 tiers of lamellulae, moderately broad (4 mm.±)., becoming slightly ventricose, adnate but becoming depressed adnate, edges a bit uneven; stipe 5–8 cm. long, 3–6 mm. thick at apex, equal or slightly narrowed below, pale dull brown, paler above, darker below, lower portion with bands of concentric patches of white fibrils from the universal veil, glabrescent at times.

Spores 7–9×4–5μ, ellipsoid, slightly roughened, pale ochraceous tawny under the microscope; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama regular, dark brownish in KOH; pileus trama similarly colored, surface layer made up mostly of inflated cells 10–30μ in dia. and 25–80μ long.

Gregarious under conifers, in deep moss, Olympic Hot Springs, Olympics, Wash., Sept. 30, 1941 (17,455) and (17,456).

Observations: The only difference between the two collections was that the universal veil remnants of 17,456 were very conspicuous. *C. musicola* is quite close to *C. flexipes* but differs markedly in the clear pale dull lavender gills which very soon loose all traces of their original color, in the lack of superficial fibrillose scales over the pileus, and lack of violaceous flesh in either the pileus or stipe at any time. I have collected *C. flexipes* on several occasions and find the colors to be as described by Ricken (1915). The only truly cinnamon brown individuals I have seen were partly faded. The collections cited above are perhaps even closer to *C. microcyclus* Fr. but differ in having close instead of distant gills, a brown instead of a white stipe, and very likely in the color of the pileus although from the information available this difference may not be great. If Herpell's spore measurements are accepted (as has been done by Rea and Ricken) then there is also a distinct difference in spore size. In view of these discrepancies, my material has been described as new.

Cortinarius subcuspidatus sp. nov.

Pileus 3–5 (7) cm. latus, conicus vel subcuspidatus, dein campanulatus vel conico-umbonatus, sericeus dein glaber, subfulvus vel subargilaceus; lamellae cinnamomeae demum fulvae, confertae; stipes 7–12 cm. longus, 4–8 mm. crassus, albosericeus vel fibrillosus, deorsum luteo-zonatus, sporae 7–9×4.5–6μ.—Specimen typicum A. H. Smith n. 17,447, legit prope Olympic Hot Springs, Olympic National Park., Wash., Sept. 30, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 3–5(7) cm. broad, prominently conic when young, soon conic campanulate or conic-umbonate with a spreading margin, seldom merely subumbonate, surface glabrous and moist on the disc, silky fibrillose toward the margin, color "snuff brown" (dull cinnamon-brown) or near "avellaneous" on the disc, more nearly "avellaneous" toward the margin hygrophanous and fading to "cinnamon-buff" (pale buff) over all and then appearing densely appressed fibrillose; flesh brittle, concolorous with the surface when moist or faded, thick under the disc but abruptly thinner toward the margin, odor none, taste mild; lamellae "Sayal brown" young, (dark cinnamon) becoming "ochraceous tawny," close, 40–44 reach the stipe, 3 tiers of lamellulae, moderately broad and becoming somewhat ventricose (5–6 mm.), bluntly adnate or developing a slight tooth, edges even or slightly eroded; stipe 7–12 cm. long, 4–8 mm. thick at apex, clavate or only slightly enlarged downward, solid but becoming hollow, sordid brown within, pallid from a dense coating of appressed silky fibrils which extends to the apex, lower portion with one to several zones of pale buff ("cinnamon-buff") universal veil remnants, these sometimes evanescent, cortina whitish.

Spores ochraceous tawny under the microscope in KOH, 7–9×4.5–6μ, ellipsoid, very slightly roughened; basidia four-spored; pleurocystidia not seen; cheilocystidia rare to absent, slightly larger than the basidia and sometimes irregular in outline, 8–12 μ broad; gill trama subparallel to interwoven, the cells enlarged, pallid tawny in KOH; pileus trama pallid tawny in KOH, the cuticle composed of a mixture of slender filamentous hyphae and others with inflated hyphal cells up to 15–20μ in dia.

Gregarious on or around rotten conifer logs, Lake Angeles Trail, Mt. Angeles, Olympics, Wash., Sept. 19, 1941 (16,969): Mt. Angeles, Sept. 24 (17,205); Sept. 26 (17,303); Sept. 28 (17,375); Olympic Hot Springs, Sept. 30 (17,447-type); Mt. Angeles, Oct. 7 (17,624) and Olympic Hot Springs, Oct. 11 (17,771).

Observations: This species is very characteristic in both the fresh and dried condition, When fresh the almost cuspidate pileus, yellowish remains of the universal veil, and the dark cinnamon gills which become tawny are its outstanding characters. It is not closely related to *C. gentilis* or *C. distans*. When dry the stipe is pallid and glistening from the appressed fibrils.

The universal veil remnants become alutaceous in drying. It is close to *C. mammosus* Kauff. but differs in usually having a sharper umbo, in the color of the gills both when young and mature, and apparently in the color of the universal veil. Although well dried, the fruiting bodies in the type of *C. mammosus* have dark dull-brown stipes, a decided contrast to those of *C. cuspidatus*.

Cortinarius subpurpureus sp. nov.

Pileus 3–5 cm. latus conicus vel convexus dein planus vel umbonatus glaber, saepe striatulatus, hygrophanus, griseo-purpureus dein ligno-brunneus; lamellae unbrino-purpureae dein fulvae, confertae; stipes 5–11 cm. longus, 8–10 mm. crassus, subclavatus, sursum purpureo-griseus, deorsum brunnescens, fibrillosus, zonis alutaceis 1–3 deorsum cinctus; sporae 7.5–9 ×5–6μ.—Specimen typicum Stuntz and Smith n. 17,781, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 3–5 cm. broad, conic to convex when young, the margin appressed against the stipe or curved in slightly, becoming broadly convex to plane or retaining an obtuse or conic umbo, silky fibrillose over all or along the margin only, but soon glabrescent, moist, translucent striate on the margin, hygrophanous, "dark vinaceous drab" (dull grayish purple) or "purple-drab," becoming "Verona brown" to "Rood's brown" (dull testaceous) and finally fading to "wood brown" (dark avellaneous) with a purplish tinge; flesh thick under the umbo or disc (5–8 mm.) but abruptly thinner away from the stipe and very watery, concolorous with the cap and fading with it, odor none, taste slight; lamellae "dark purple-drab" (deep grayish purple) but soon becoming "Rood's brown" (dull testaceous) and finally "ochraceous tawny," close, 2 tiers of lamellulae, bluntly adnate, ascending or horizontal, seceding, moderately broad (5 mm. ±); stipe 5–11 cm. long, 8–10 mm. thick, at the apex, narrowly clavate, solid but becoming hollow, "purple-drab" over all but soon sordid brown below and over all in age, lower half densely white fibrillose and with "cinnamon-buff" (dull yellowish buff) zones of universal veil tissue, appressed silky above, sometimes coarsely silky fibrillose from remains of the cortina.

Spores 7.5–9×5–6μ, dark rusty brown under the microscope, slightly roughened, broadly ellipsoid to subovoid; basidia four-spored; cheilocystidia and pleurocystidia not differentiated; gill trama regular to subregular, dull tawny in KOH, subhymenium somewhat cellular; pileus trama very distinctive, tramal body composed of interwoven hyphae with brownish walls when revived in KOH, cuticle composed of two layers of hyaline cells (revived in KOH), those over the surface slender (3–6μ) and radially arranged in an indefinite layer several cells (more or less) thick, between this layer and the brownish hyphae of the tramal body is found a layer of in-

flated hyaline cells (more or less barrel-shaped) 30–60×20–40μ. thin walled and radially arranged, the layer 2–3 cells thick.

Gregarious under conifers, Olympic Hot Springs, Olympics, Wash., Sept. 30, 1941 (17,462); same place and locality (17,463-convex form), Oct. 8 (17,712); Oct. 11 (Stuntz and Smith 17,781-type); Oct. 15 (17,915) Oct. 17 (18,001).

Observations: This was a common and easily recognized species in the field, and appears to be close to *C. pericelis*. The latter, however, is said to have pallid instead of violaceous gills. There should also be a distinct difference in stature, the Friesian species being much more slender than *C. subpurpureus*. In Kauffman's (1932) key it seems to be closest to *C. injuncundus* by virtue of its colored veil and violaceous gills, but differs in the color of the pileus and stipe, and in the organization of the trama of the pileus.

Cortinarius distans var. **olympianus** var. nov.

Pileus 3–6 cm. latus, conicus dein campanulatus, substriatus, furfuraceus, rufo-fulvus demum pallide fulvus; lamellae subtestaceae dein fulvae, latae, subdistantes, adnatae demum secedentes; stipes (5) 8–12 (14) cm. longus, 8–11 (15) mm. crassus, subaequalis, subfulvus; sporae 7–9×5–6μ. —Specimen typicum A. H. Smith n. 17,523, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 3–6 cm. broad, broadly conic when young, conic campanulate or subexpanded with a sharp conic umbo in age, surface moist and hygrophanous, minutely furfuraceous over all in either moist or faded condition, faintly striatulate on the margin, color "russet" to "hazel" over all when moist (dark to bright rusty brown), becoming "tawny" at least along the margin before fading, "ochraceous tawny" over all when faded; flesh thin, concolorous in either moist or faded condition, taste mild, odor strong of radishes; lamellae "Verona brown" (dull cinnamon), "tawny" at maturity, broad (6–8 mm.), broadest at attachment and tapered to the margin, subdistant, 23–26 reach the stipe, 2 tiers of lamellulae, adnate but becoming slightly adnexed and with a decurrent tooth, soon seceding; stipe (5) 8–12 (14) cm. long, 8–11 (15) mm. thick at apex, equal or gradually enlarged downward, hollow, dark yellowish brown over all (more or less concolorous with the pileus), with a median or superior rusty yellow fibrillose ring, silky above, becoming dark rusty brown and glabrescent where handled, mycelium whitish.

Spores very broadly ellipsoid and dark rusty brown under the microscope, 7–9×5–6μ, tuberculate roughened; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama regular; pileus trama homogene-

ous, the surface layer of compact radially arranged hyphae, the walls dark rusty brown from incrusting pigment.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 2, 1941 (17,523-type) and again Oct. 11 (17,803).

Observations: Pilei of the variety dry a more reddish brown ("carob-brown" to "liver brown") than typical material which is "cinnamon-buff" to "clay-color" when dried. This difference along with the rusty yellow fibrillose ring, the subdistant rather than distant gills, and the discoloration of the stipe when handled distinguishes the variety from typical material. Kauffman emphasized that the universal veil in the typical variety was concolorous with the carpophore but that when it broke the ring left on the stipe was whitish. In my own collections of typical material from both Michigan and Oregon this observation has been verified. Thus the difference in color of the veil remnants appears greatest in mature carpophores. *C. helvolus* is apparently very close but is characterized by thickish gills and lack of a raphanoid odor. In fact, var. *olympianus* seems to be intermediate between these two. It has the colored fibrillose zone of *C. helvolus* as well as the fusco-ferruginescent flesh in the base of the stipe. It is difficult to determine from the information at hand whether or not there really is much difference in the colors of the pileus between *C. distans* and *C. helvolus*. *C. distans* belongs to the series of bright colored Cortinarii around *C. gentilis* and is totally distinct from *C. brunneus* and other similar species. *C. croceo-fulvus* Fr. appears to be very close also, but is not described as either striate or furfuraceous.

Cortinarius hemitrichus var. **americanus** var. nov.

Pileus (2.5) 3–6 cm. latus, campanulatus dein umbonato-expansus, fibrillosus vel squamulosus demum glaber, rufo-fulvus dein helvolus; lamellae cinnamomeae, confertae, latae; stipes 5–8 cm. longus, (4) 6–10 mm. crassus, aequalis, albo-peronatus; sporae 5.5–7.5×4–5.5μ, late ellipsoideae.—Specimen typicum A. H. Smith n. 17,669, legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941; in Herb. Univ. of Mich. conservatum.

Pileus (2.5) 3–6 cm. broad, conic with an inrolled margin, becoming conic campanulate, in age plane with a conic umbo or the margin finally broadly recurved, surface covered by a thin coating of white fibrils which become more or less aggregated into appressed scales before weathering away, glabrescent, smooth, moist, hygrophanous, margin opaque, "russet", (rusty brown) when young, "Sayal brown" (dark cinnamon) at maturity and fading to near "cinnamon" (cinnamon color or paler) and eventually sordid tan; flesh thick in the umbo, tapered abruptly away from it (1.5–2 mm. near the stipe), moderately firm and rigid, concolorous with the surface, odor none, taste mild; lamellae "Sayal brown" when young (dark

cinnamon) becoming more or less ochraceous tawny in age, adnate to depressed adnate, moderately broad, (5–7 mm.), broadest near the stipe, moderately close, 41–46 reach the stipe, 2–3 tiers of lamellulae, intervenose at times, edges even, sometimes spotted or stained dark brown; stipe 5–8 cm. long, (4) 6–10 mm. thick, equal, pale brown within and soon hollowed, surface peronate over lower half with a white sheath of universal veil remnants, sheath terminating in a median fibrillose zone, thinly appressed white-fibrillose above and soon glabrescent, becoming more brownish over all in age but not darkening any more in the base than elsewhere.

Spores 5.5–7.5×4–5.5μ, broadly ellipsoid, nearly smooth, pale rusty brown under the microscope; basidia four-spored; cheilocystidia scattered to clustered, clavate, thin walled, hyaline, 26–38×7–10μ; pleurocystidia not seen; gill trama regular, pallid brownish in KOH; pileus trama homogeneous, brownish in KOH; surface hyphae radially arranged into a compact cuticle, the hyphae more or less the same diameter as those of the tramal body.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941 (17,669).

Observations: The variety appears to be very abundant in the Olympics whereas typical material was not found. Scattered groups of mature fruiting bodies were repeatedly observed in the region around Olympic Hot Springs, but coll. 17,669 was the only one encountered in which young material was abundant. The variety is distinguished by the small broadly ellipsoid spores and apparently by slightly different colors. It is close to *C. rigidus* sensu Ricken in certain respects. However, the lack of an odor, the presence of copious universal veil remnants over the pileus and generally more robust stature exclude *C. rigidus* from consideration. *C. stemmatus* has darker and redder colors, a not so conspicuously fibrillose pileus and distinctly larger spores. My specimens were compared with *C. hemitrichus* collected in Sweden by Kauffman. The spores of the latter are larger and more almond-shaped. Judging from the descriptions of various authors, who nearly all disagree in regard to minor characters of *C. rigidus* and *C. hemitrichus*, there are numerous local forms and varieties of these species, Kauffman's (1932) description of *C. hemitrichus* reads as though it were taken from a pale form of var. *americanus* rather than from his Swedish collection. *C. hemitrichus* sensu Henry (1934) has spores like Kauffman's Swedish collection. Consequently his account is accepted as applying to the typical variety. The spore size given in Saccardo very likely indicates that var. *americanus* also occurs in Europe.

Cortinarius nigrellus var. **occidentalis** var. nov.

Pileus 1–3 cm. latus, obtusus vel convexus, sericeus dein glaber, umbrino-castaneus demum testaceus; lamellae argillaceae vel cinnamomeae,

confertae, latae, adnatae; stipes 4–7 cm. longus, 3–5 mm. crassus, subaequalis, vinaceo-annulatus, sursum pallidus dein brunneus, deorsum subfuscus; sporae 7–8×5–6μ.—Specimen typicum A. H. Smith n. 17,304, legit prope Olympic Hot Springs, Olympic National Park, Wash., Sept. 26, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1–3 cm. broad, obtusely conic with an incurved margin when young, becoming convex to obtusely umbonate, surface silky fibrillose and more or less radially wrinkled in some, "carob brown" to "liver brown" over all when moist (deep chestnut to testaceous), the margin sometimes a paler deep reddish brown, hygrophanous, fading to "cameo brown" or "cacao brown" (cocoa-color), margin for a time appendiculate with veil fragments; flesh thick on the disc, thin on the margin, more or less dull yellowish brown ("snuff brown") moist or with a reddish tinge, fading to "clay color" (paler yellowish brown), odor and taste not distinctive; lamellae "clay color" young, becoming nearly "Sayal brown" at maturity, not staining, moderately close, 43–48 reach the stipe, 1–2 tiers of lamellulae, broad (4 mm. ±), adnate but becoming adnexed, edges even; stipe 4–7 cm. long, 3–5 mm. thick at the apex, slightly enlarged downward, stuffed, pith "clay color," cortex pallid, surface more or less pallid and fibrillose, cortina whitish, universal veil dull vinaceous red and leaving a vinaceous median fibrillose zone, apex silky and becoming pale sordid brownish.

Spores pale ochraceous tawny under the microscope, 7–8×5–6μ, broadly ellipsoid to subglobose, roughened; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama subregular; pileus trama homogeneous, the surface hyphae compactly and radially arranged.

Gregarious under conifers, Mt. Angeles, Olympic Mts., Wash., Sept. 24, 1941 (17,193) and Sept. 26 (17,304-type).

Observations: The color of the universal veil is almost identical with that of the typical variety. In the dried specimens it is more or less "fawn color" rather than bright reddish as in *C. haematochelis*. Var. *occidentalis* differs from typical material in the more reddish brown pileus, more yellowish brown gills, and slightly shorter and broader as well as paler spores. The difference in the color of the spores under the microscope is very striking. The difference between "avellaneous" to "fawn color" in the young gills of typical material and "clay color" in the variety is also important. Neither *C. nigrellus* nor the variety *occidentalis* can be referred to synonymy under *C. rigidus* because of their vinaceous universal veils.

CORTINARIUS ADUSTUS Pk. Ann. Rep. N. Y. State Mus. **42**: 22. 1889.

Pileus 3–7 cm. broad, obtuse or with a flattened disc and an inrolled margin, becoming broadly umbonate or nearly plane and sometimes with a wavy margin, surface glabrous and moist, with watery streaks toward the margin, color "Brownish drab" to "light brownish drab" (dull viola-

ceous brown), becoming "army brown" on the disc (deep vinaceous brown), scarcely fading; flesh thick, more or less purplish young ("pale purple-drab"), sordid dull watery brown in age and watery punctate, odor none, taste mild; lamellae "pale purple-drab" or more lilaceous when young, "Rood's brown" at maturity (deep vinaceous brown), close, 65–72 reach the stipe, 2 tiers of lamellulae, narrow to moderately broad and more or less ventricose (5–7 mm.), sharply and deeply adnexed, edges uneven; stipe 7–10 cm. long, 9–18 mm. thick at apex, narrowly clavate (occasionally 30 mm. at base), some nearly equal, solid, apex silky-fibrillose and concolorous with the young gills, lower portion covered by a white or pallid sheath of universal veil fibrils, glabrescent, more or less concolorous with the pileus, interior pallid vinaceous brown in the base, in the apex dull lilac at first.

Spores 7–9×4–5μ, ellipsoid, slightly roughened, dull bister under the microscope in KOH; basidia four-spored; pleuro- and cheilocystidia not differentiated; basidia and gill trama dull brown in KOH; pileus trama dull brown and with scattered enlarged cells near the surface or a more or less distinct cellular layer (in tangential section) present, the cells 8–20μ in dia.

Gregarious under conifers, Olympic Hot Springs, Oct. 11, 1941, Stuntz and Smith (17,776).

Observations: This species is very similar to *C. torvus* in color and in the way the fruiting bodies dry, but can best be distinguished by the lack of an annulus. The veil remnants form only an evanescent zone. Peck in his description of *C. adustus* gave the spore size as up to 10μ (.0004 inch) long. Kauffman separated Peck's species from *C. scutulatus* Fr. chiefly on the basis of spore size. He ascribed spores 7–8×4–4.5μ to the Friesian species and spores 8–10×5.5–6.5μ to that of Peck. The type of Peck's species has been examined and the spores found to be 7–8 (9)×5–5.5μ. Henry (1938 b) has recently described what he considers to be typical *C. scutulatus* with spores 9–11×6.5μ. Thus it now appears that the spore measurements given in the North American Flora for these species should be reversed. However, it is also evident that *C. scutulatus* is amply distinguished from *C. adustus* by the copious universal veil fragments left on the stipe as the sheath breaks up. Since this character goes back to the Friesian descriptions, whereas spore size does not, it should be given the most emphasis in determining which of the two should be regarded as *C. scutulatus*. This leaves *C. adustus* with few characters to really distinguish it from *C impennis* Fr., a fungus with much the same colors and only a slightly developed universal veil. *C. impennis* has distant gills, *C. adustus* as described has subdistant gills, and in the Olympic collections they were close. Consequently the latter are placed in *C. adustus*. However, a fungus I have identified as *C. impennis* has also been collected in the Olympics. Its slightly smaller spores and more distant gills appeared distinctive,

but not all authors are agreed that *C. impennis* has small spores. For additional comments see *C. impennis*, page 223.

CORTINARIUS BIBULUS Quélet Champ. Jura et Vosges, Suppl. 10, p. 666. 1880.

Cortinarius americanus Smith, Ann. Myc. **22**: 471. 1934.

Lange (1938) placed *C. americanus* in synonymy with *C. pulchellus*, a species he had previously described. More recently Singer (1937) referred both *C. pulchellus* and *C. americanus* to *C. insignis* Britz. (in the revised sense of the latter author). Killerman (1928) however, placed *C.* (*Hydrocybe*) *insignis* in synonymy with *Inocybe geophylla*, a rather plausible disposition of it if one considers the lilac form of the latter. It is questionable whether *C. insignis* Britz. can be recognized as a valid name. Obviously the large fungus originally described under that name is distinct from the small species of the Revision (1899). If the concept established in the "Revision" is accepted, it is still questionable whether either *C. pulchellus* or *C. americanus* can be legitimately referred to it. *C. insignis* was described as lilac-flesh colored, whereas the other two species as I know them from fresh material are a dull violet with little or no vinaceous tints evident. Consequently it appears best to either discard the name *insignis* or accept Killerman's disposition of it. In regard to *C. pulchellus* and *C. americanus* the only significant difference appears to be in the development of the universal veil. However, in my collections of both the difference appeared to be constant and since the character is used to distinguish the subgenera Telamonia and Hydrocybe it is logical to accept it as sufficient evidence to separate the two species in question. Further studies, however, convinced me that *C. americanus* is not specifically distinct from *C. bibulus* Quél. The latter was overlooked in my first study of *C. americanus*. Although I have not seen material of *C. bibulus* the plate and description are convincing enough. The spores of *C. bibulus* may be slightly smaller than in the American material, and the veil remnants on the stipe more copious but these differences do not appear to be distinctive. In *C. americanus* the universal veil remnants usually form a single distinct fibrillose zone with only a few flecks of fibrils toward the base of the stipe or the latter is merely silky downward. The cortina is very scanty and collapses on the stipe above the remains of the universal veil. Actually the American Telamonia is intermediate in its veil characters between the fungus shown in Quélet's plate and that of Lange. This situation brings into focus the difficulties of trying to establish natural relationships in the genus Cortinarius. All along the dividing line between Telamonia and Hydrocybe one finds examples of two or more obviously closely related species being placed in separate subgenera. The study of such groups has interested me for some time, but it is greatly complicated by

the duplication of stature and color throughout all the subgenera of the genus, and can be carried out satisfactorily only on fresh material.

CORTINARIUS BOVINUS Fr., Epicrisis Syst. Myc., p. 297. 1838.

Pileus 4–8 cm. broad, obtuse when young, becoming nearly plane or broadly umbonate at maturity, surface appearing dry from appressed fibrils especially near the margin which is more or less fringed with "clay color" to pallid fascicles of fibrils, colors dull brown to dull tan (near "cinnamon-brown" on the disc, margin near "clay color"); flesh thick, brittle, watery-brown, fading to near "wood brown" (hygrophanous), odor and taste not distinctive; lamellae subdistant, 3 tiers of lamellulae, broad, adnexed, "avellaneous" (grayish brown) or darker when young, pale cinnamon-brown in age, edges fimbriate; stipe 5–8 cm. long, 1–2 cm. thick at apex, 2–3 cm. at base, solid, watery-punctate and pale dull brown within (near "wood brown"), lower portion belted with pale buff ("cinnamon-buff") fibrillose rings from the universal veil, coarsely silky fibrillose and more or less avellaneous over all beneath the universal veil remnants.

Spores 8–10×6–7μ, very broadly ellipsoid, tuberculate roughened, dark rusty brown in KOH under the microscope; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama regular; pileus trama homogeneous, hyphae of cuticle not particularly enlarged.

Gregarious to subcespitose, under hemlock, Timberline Camp, Mt. Baker, Wash., Aug. 24, 1941 (16,348).

Observations: Lange described the universal veil remnants as forming a white band on the stipe, a character not in accord with the Friesian descriptions. In my material the universal veil was "clay-color" (alutaceous) and hence possibly even more brownish than indicated by the descriptions of Fries and Rea. The difference, however, does not appear significant in view of the wide range of color included under the term fuscous by Fries and later mycologists. My specimens also appeared to have a denser fibrillose covering over the pilei than is usually indicated in the European manuals. Here again, however, considerable variation can be reasonably allowed.

CORTINARIUS BRUNNEUS Fr., Epicrisis Syst. Myc., p. 298. 1838.

Pileus 3–6 cm. broad, obtusely conic with an incurved margin when young, becoming broadly conic-campanulate or with a broad obtuse umbo and spreading margin, surface white-silky fibrillose along the margin but less so toward the disc, moist and hygrophanous but margin opaque, evenly "walnut brown" (dull testaceous), fading slowly (on the disc first) to dull tawny, the whitish fibrils more conspicuous in faded plants; flesh thick on the disc, tapered abruptly and thin over the remainder, dull walnut brown moist, fading to whitish, odor and taste not distinctive;

lamellae dull brown with a tinge of purplish at first, paler and more cinnamon brown in age, subdistant, 47–53 reach the stipe, 3 tiers of lamellulae, broad (6–8 mm.), broadest at base and tapered to the margin, rather deeply adnexed and toothed, the edges nearly even; stipe short, 4–6 (7) cm. long, 9–13 mm. thick at apex, clavate or nearly equal, solid or becoming hollow, lower portion whitish from the sheath left by the universal veil remnants, sheath terminating in a median fibrillose zone which soon discolors slightly, apex appressed silky and pallid, interior of apex "vinaceous brown" or with a distinct violet tinge causing the surface to appear obscurely violet-brown beneath the silky fibrils, dull sordid brown within toward the base and in age dull brown over all including the veil remnants.

Spores 7–9×5–6μ, broadly subellipsoid, dull rusty brown under the microscope, slightly roughened; basidia four-spored; pleuro- and cheilocystidia none seen; gill trama regular, brownish in KOH; pileus trama with a surface layer of more or less enlarged cells (9–25μ) in tangential section, otherwise homogeneous.

Gregarious under second growth Douglas fir, Mt. Angeles, Olympic Mts., Wash., Sept. 24, 1941 (17,198).

Observations: The color of the veil changes from whitish to pallid dull brownish as the carpophores age. Hence it is not surprising to find some descriptions giving its color as white (Lange) and others (Kauffman) fuscous. Fries (1874) described it as "fusco-albo." The purplish to violaceous brown tinge in the gills and apex of the stipe is obscured and a bit confusing but hardly pronounced enough to cause one to search for the species among those having truly violaceous or lilac gills. *C. brunneus* and *C. bovinus* according to the material I have seen can be separated by the distinctly colored universal veil of the latter in young stages, lack of testaceous tints in the fruiting body and by the homogeneous pileus.

CORTINARIUS GLANDICOLOR var. CURTUS Fr., sensu Lange, Flora Agaricina Danica 3: 40, Pl. 97, fig. D. 1938.

Pileus 10–25 mm. broad, obtuse, becoming plane or slightly umbonate, margin incurved slightly, surface covered by a thin coating of more or less appressed white fibrils, margin whitish from veil remnants, color beneath the fibrils "bone brown," "dusky brown" or "blackish brown (1)" (very dark blackish brown with only a tinge of testaceous, fading slowly to a grayer brown, about "wood brown"); flesh concolorous with surface but paler grayish when faded, rather firm and rigid, tapered abruptly off the disc and very thin, odor and taste not distinctive; lamellae "bister" to "Hay's brown" (very dark dull brown with a testaceous cast when partly mature), becoming "cinnamon-brown" at maturity but remaining rather dark for a long time, more or less subdistant, 21± reach the stipe,

2 tiers of lamellulae, some forked, moderately broad and becoming ventricose, thickish, edges even; stipe 3–5.5 cm. long, 2.5–3.5 mm. thick, equal, tubular, concolorous with the pileus beneath a dense white fibrillose coating, usually with a distinct white fibrillose zone around the mid-portion from the universal veil remnants, glabrescent, blackish within.

Spores 7–9×4–5 μ, ellipsoid, very slightly roughened, pale ochraceous tawny under the microscope; basidia four-spored; pleurocystidia none or present only as basidia-like cells with a dark brownish amorphous content; cheilocystidia none; gill trama regular, very dark brown in KOH (dark to light bister); pileus trama also dark brown, the surface layer indefinite and composed of inflated cells 20–40×30–90μ, many narrower and longer cells intermixed, the hyphae radially arranged.

Gregarious under second growth Douglas fir, Mt. Angeles, Olympics, Wash., Sept. 24, 1941 (17,201); Joyce, Wash., Sept. 29, 1941 (17,393).

Observations: Only the two small collections were made. My material was a little slenderer in stature than that described by Lange, but all other characters are in agreement. Lange did not give information of the trama of the pileus so no comparison can be made on that character. He cited the authority as "Fr. sensu Rea" but since Rea (1922) did not give the spore size it is not desirable to base a concept on his description, at least not one in which the spore size of the variety is different from that given in Rea's description of the species. The obscure violaceous tone usually present is quite confusing and sometimes might lead one to place his collection in *C. flexipes*. However, the latter is distinctly violaceous at first. *C. rigidus* is also close, but is readily distinguished by the paler gills when young and paler more reddish brown pilei. In many respects, this variety could be referred to *C. stemmatus*. It differs in the less conspicuous universal veil remnants on the stipe.

CORTINARIUS HAEMATOCHELIS Bull. ex Fr., sensu Bres., Icon. Myc. **14**: pl. 652. 1930.

Pileus 3–6 (8) cm. broad, obtuse with a somewhat incurved margin when young, becoming partly expanded, usually with a broad somewhat flattened umbo and a more or less decurved margin, sometimes merely broadly convex to plane, surface slightly moist but not typically hygrophanous, "Mikado brown" on the disc and with a paler margin (toned with avellaneous) the vinaceous brown gradually giving way to fuscous shades (nearly "hair brown" when dried), glabrous or fibrillose streaked, in age the disc sometimes with spotlike scales; flesh thick on the disc (6 mm. ±), abruptly thinner away from the stipe, watery punctate and pale brown moist, ("wood brown") fading to pallid with a vinaceous tinge ("vinaceous buff"), odor and taste not distinctive; lamellae pale cinnamon brown ("Sayal brown") young, dark cinnamon brown in age, adnate,

depressed–adnate or in age adnexed, broad (7 mm. ±), broadest in midportion but edges more or less horizontal, close, 42± reach the stipe, 2 tiers of lamellulae, edges slightly eroded; stipe clavate, 5–8 (10) cm. long, 5–9 (12) mm. thick at apex, base 15–25 mm., pallid over all from a silky-fibrillose coating in part at least from the remains of the cortina, with 1–2 belts of vinaceous brown ("Pecan brown" to "vinaceous tawny") universal veil remnants.

Scattered under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941 (17,457); Oct. 2 (17,530); Mt. Angeles, Olympic Mts., Wash., Oct. 4, (17,562); Sol Duc Hot Springs Olympic National Park, Oct. 6 (17,597); Olympic Hot Springs, Oct. 8 (17,659) and 17,709); same locality Oct. 11 (17,767) and Oct. 15, 1941 (17,909).

Observations: *C. haematochelis* has been considered a synonym of *C. armillatus* by some investigators, but Bresadola has recognized it as a distinct species because of the small spores. Bulliard's original plate does not help much in identifying either *C. armillatus* or *C. haematochelis* since the colors do not match those of either species. Hence there is nothing to be gained by comparing specimens with his illustrations. The same may be said for the descriptions. This, however, can be attributed to the similarity in the appearance of the two species. The question, then, is not whether Bulliard's fungus is distinct from *C. armillatus*, but instead is purely nomenclatorial. Should a new name be given to the species Bresadola placed in Bulliard's species, or should Bresadola's use of the name *C. haematochelis* be followed? In order to avoid multiplication of names in an already very large genus the latter choice is followed here.

I have collected *C. armillatus* in great quantities in northern Michigan and in smaller amounts in Ontario, Nova Scotia, New York and Tennessee, but have not encountered it along the west coast. Kauffman (1932) reported it from "New England and Canada to Pennsylvania and Minnesota." Its absence in the Olympics in 1941 was noticed particularly since I desired to make a comparison of fresh specimens of both species.

CORTINARIUS HELVOLUS Fr. sensu Bres., Icon. Myc. **14**: pl. 653. 1930.

Pileus 3–4.5 cm. broad, broadly conic when young, becoming plane with a broad low but conic umbo, surface with a thin white-fibrillose silky coating (which is very inconspicuous), moist and hygrophanous, faintly striate, "chestnut" (deep reddish brown) but soon becoming "amber brown" (bright yellowish brown); the disc usually darker than the margin fading to "ochraceous tawny" or more or less pale tawny; flesh thin and fragile, nearly equal or tapered gradually to the margin, "amber-brown" fading to "warm buff" (yellowish) odor and taste not distinctive; lamellae "amber-brown" young, becoming "ochraceous tawny" (none were very old), bluntly adnate to slightly depressed, subdistant, 28± reach the

stipe, 2 tiers of lamellulae, narrow to broad (6 mm. ± in the largest cap), somewhat ventricose, edges even; stipe 4–7 cm. long, 6–9 mm. at apex, equal or slightly enlarged to the base, hollow, fragile, readily splitting, "clay color" within (dull yellowish brown), surface at first with a thin coating of pallid fibrils over all and a submedian faint fibrillose zone, glabrescent and then more or less concolorous with the pileus.

Spores 6–8×3.5–4.5μ, narrowly ellipsoid to slightly ventricose, almost smooth, pale brown under the microscope; basidia four-spored; gill and pileus trama dark cocoa-color (very deep testaceous near the surface of the pileus); pileus trama practically homogeneous.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Sept. 30, 1941 (17,463).

Observations: In the field this species impressed me as being closely related to *C. gentilis*, but it dries a deep dull fuscous brown somewhat like *C. uraceus*. The spores are very distinctive and separate it at once both from *C. rubricosus* and *C. gentillis*. The universal veil is so thin that one is likely to seek first in Hydrocybe when identifying specimens. As a rule most Cortinarii with distinctly yellowish colors dry a pale brown or a decidedly yellowish brown. Concepts of *C. helvolus* differ somewhat. Ricken described it as having large spores, and Rea as having a ferruginous fibrillose zone on the stipe. Bresadola illustrates a pallid zone although he indicated in his description that the fibrils are yellowish at times.

CORTINARIUS IMPENNIS Fr., Epicrisis Syst. Myc., p. 293. 1836.

Pileus 3–6 (8) cm. broad, convex with an inrolled margin, becoming broadly convex to nearly plane, sometimes broadly umbonate, surface glabrous and variegated with watery streaks, when moist and fresh "Ecru drab" to "light cinnamon-drab" (pale to dark purplish umber), soon developing dull testaceous shades ("Vandyke brown" on the disc to "Rood's brown" toward the margin when still moist), fading to near "Sayal brown" or dull "cinnamon buff" (pale dark cinnamon with a prevading violaceous gray tone), the margin often fringed with violaceous-gray fibrils; flesh thick in the disc, thinner toward the margin, watery punctate before fading, purple to dull violet young, becoming grayish-purplish to "pale brownish drab," finally dull testaceous ("army brown") before fading to avellaneous, odor none, taste mild; lamellae "purple-drab" to "light purple-drab" and becoming "army brown" (deep dull testaceous-purple brown), broad (up to 1 cm.) bluntly adnate then becoming adnexed, distant, 28–35 (41) reach the stipe, 3 tiers of lamellulae, intervenose, edges even or crenulate, solid, when young dark purple to purplish umber throughout (concolorous with young gills), soon dull brownish below and in age pallid dull violaceous-vinaceous, surface more or less appressed fibrillose, usually with an evanescent median fibrillose to submembranous

zone from the veil, part or all of veil remnants may adhere to the margin of the pileus.

Spores 8–10.5×5–6.5μ, broadly ellipsoid, dark rusty under the microscope, roughened; basidia four-spored; pleurocystidia not differentiated or merely as basidia-like cells with dull brown content when revived in KOH, cheilocystidia clustered, thin walled, saccate to mucronate, 18–30× 6–12μ; gill trama regular, faintly vinaceous brown in KOH; pileus trama homogeneous and colored like the gill trama in KOH.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 11, 1941 (Stuntz and Smith 17,780); Oct. 15 (Smith 17,923) and Oct. 17 (18,010).

Observations: *C. impennis*, *C. torvus* and *C. adustus* appear to be very closely related. *C. torvus* is readily distinguishable by its stature and membranous annulus, but is similar in spore size and in having the vinaceous reaction of the gills and pileus trama to KOH. Apparently the homogeneous pileus and cheilocystidia along with the distant gills distinguish *C. impennis* from *C. adustus*, but the type of the latter was not studied with these characters in mind, and since the cheilocystidia appear to be sporadic in their appearance in *C. impennis* they might not be present on the type specimens of *C. adustus* even though the two species were actually identical.

CORTINARIUS MORRISII Pk., Bull. Torr. Bot. Club **32**: 79. 1905.

Gregarious under hemlock, Boulder Creek Trail, Mt. Baker, Wash., Aug. 24, 1941 (16,347); Sandy Creek Trail, Mt. Baker, Wash., Aug. 30 (16,472); Olympic Hot Springs, Olympic National Park, Wash., Sept. 22, 1941 (17,168).

Observations: This is a characteristic Cortinarius in the same series as *C. gentilis* and *C. distans* but larger than either when well developed. It differs from *C. distans* var. *olympianus* in having "honey yellow" rather than "Verona brown" (pale yellow in contrast to dark dull brown) gills when young and in the pileus not being furfuraceous. Sometimes one is very likely to seek for *C. Morrissii* in the subgenus Hydrocybe because of the lack of universal veil remnants on the stipe in even rather young carpophores. When present the universal veil remnants are in the form of an inferior zone of scattered yellowish to tawny flecks. The pilei are "Sanfords brown" to "tawny" when moist and sometimes become "hazel" in age. The spores measure 8–10×5.5–6μ. *C. croceofulvus* as illustrated by Cooke (Illus. no. 1191, t. 1193) is very similar and may be identical. It is said to have spores the size of those of *C. Morrissii*, but no mention is made of its taste. *C. confusus* Kauff. and Smith is also very close but has smaller spores (7–8μ long), and lacks the radish-like taste of *C. Morrissii*.

CORTINARIUS RUSTICUS Karst., Symb. Myc. Fenn. 9: p. 45. 1883.

Pileus 5–8 cm. broad, convex, becoming broadly convex, margin inrolled at first, surface moist and hygrophanous, at first with a thin coating of grayish fibrils, opaque at all stages, "Sayal brown" (dark cinnamon) moist or appearing "wood brown" or "cinnamon-buff" (pale buff) margin for a time appendiculate with shreds of the cortina; flesh thick, watery punctate and dull brown, pale buff when faded, odor none, taste mild; lamellae "avellaneous" (dull grayish brown) young, "Sayal brown" at maturity (concolorous with the pileus), adnexed, moderately broad, 4–6 mm., subdistant to close, lamellulae often crisped, 66± reach the stipe, 3 tiers of lamellulae, edges even; stipe short, 3–6 cm. long, 1–2 cm. thick at apex, clavate, solid, watery brown within, apex silky and pale brownish, whitish below at first from the thin universal veil, brownish as the fibrils disappear, with an inferior white-fibrillose zone of universal veil remnants.

Spores 9–11×5–6.5μ, subamygdaliform, dark rusty brown under the microscope in KOH, tuberculate roughened; basidia four-spored; cheilocystidia and pleurocystidia not differentiated; gill trama subregular; pileus trama practically homogeneous, the surface cells only slightly enlarged.

Gregarious under spruce, near Lick Creek Summit, Idaho National Forest, Idaho, Elev. 6500 ft. ±, Aug. 3, 1941 (15,963 and 15,982).

Observations: This species is dull dark cinnamon over all. In drying, carpophores of 15,982 became blackish much after the manner of *C. impennis* and *C. torvus*. It appears to be very similar to *C. injucundus* but differs in the color of the gills and their spacing and in having a white instead of a colored universal veil. *Telamonia iliopodia* sensu Ricken differs in its hollow stipe, smaller spores and yellower gills. From *T. bivela* sensu Ricken *C. rusticus* differs in its paler and duller gills and decidedly hygrophamous pileus. Fries' illustration (1877) of *C. bivelus* apparently depicts faded specimens. *C. rusticus* is described as having pallid cinnamon gills at first. This apparently is more of a cinnamon color than that observed on the youngest specimens in my collections but on the other hand it is exactly the color the gills assume as they mature, and hence no significance is attached to the difference. Apparently the universal veil is better developed in the material Karsten described, but this difference also appears to be of little significance taxonomically. The species may be only a variety of *C. bivelus* Fr. *C. Hillieri* Henry should be readily distinguishable by its characteristic odor although in its other characters it is apparently very similar to both *C. bivelus* and *C. rusticus*.

CORTINARIUS STEMMATUS Fr., Epicrisis Syst. Myc., p. 309. 1836.

Pileus 3–5 cm. broad, obtusely campanulate when young, becoming

broadly conic campanulate or in age nearly plane with an obtuse umbo, margin incurved when young and usually remaining decurved, surface coated thinly with whitish fibrils over the disc, margin conspicuously white-fibrillose, appearing "benzo-brown" when young because of the fibrils, "bone brown" (very dark dull brown) when the fibrils are removed, fading slowly to "chestnut brown" or "Rood's brown" (becoming redder as it fades), streaked when fading but not striate; flesh more or less concolorous with the surface but fading to "pale pinkish buff" (pale buff), thick in the disc and tapered abruptly, odor none, taste mild; lamellae "seal brown" in buttons (vinaceous umber), becoming "wood brown" (dark avellaneous) and finally "Sayal brown" (dark cinnamon) from the spores, moderately close, 40–44 reach the stipe, 2–3 tiers of lamellulae, horizontal, moderately broad, (6–7 mm.), sharply adnexed, edges wavy; stipe 5–8 cm. long, 4–9 mm. thick, equal, solid but hollowed by grubs, near "benzo brown" (dull violaceous brown) within but fading like the pileus, surface pallid from a dense coating of appressed white fibrils, lower half shaggy-fibrillose or with zones or patches of white fibrils from the universal veil, apex silky.

Spores 7–9 (10)×4–5.5μ, subamygdaliform, dull tawny under the microscope; basidia four-spored, pleuro- and cheilocystidia not seen; gill trama regular, very pale brown in KOH; pileus trama pale brown except for the surface layer of slightly enlarged cells (9–15μ).

Densely gregarious under alder and Douglas fir, Mt. Angeles, Olympics, Wash., Sept. 21, 1941 (17,125 and 17,126).

Observations: This fungus, very common in the Olympics and with slightly redder and paler colors than *C. palaceus* must be *C. stemmatus* Fr. The colors fade very slowly and change remarkably in tone. One group of about fifty fruiting bodies near my laboratory was observed for a week. When first found the pilei were just developing and were nearly fuscous. This shade remained constant for several days and then very gradually faded to dull testaceous and then to a paler reddish cinnamon-color. The close gills distinguish it from *C. glandicolor*. The latter is generally described as having a single zone of fibrils on the stipe from the ruptured universal veil. *C. stemmatus* either has a very shaggy-fibrillose stipe or the veil remnants are aggregated into several zones. *C. palaceus* as I know the latter can be readily recognized by its smaller ellipsoid spores and more pronounced fibrillose veil remnants on the cap. *C. washingtonensis* Smith is readily distinguished by it violaceous tints in the stipe, by the gills staining blackish when bruised and by its smaller spores. Henry (1937) points out that the apex of the stipe has an obscure violet reflection in *C. stemmatus*. The same was noted on my collections but is difficult to match in any color chart. The colors of the very young gills in my collections also had the same obscure violaceous cast but this was soon lost.

C. castaneoides Pk. appears to be very closely related but is distinguished by its smaller (6–7.5×3.5–4.5μ) spores and yellowish gills.

HYDROCYBE

Cortinarius boreasensis sp. nov.

Pileus 3–7 cm. latus, obtusus dein umbonatus, vel convexus, rufo-fulvus vel subtestaceus demum cinereo-cinnamomeus; odor distinctissimus, fragrans; lamellae subumbrino-violaceae dein ferrugineae, subdistantes, angustae vel sublatae; stipes 2–7 cm. longus, 4–8 mm. crassus, subclavatus, sordide brunneus, sericeo-fibrillosus; sporae 8–9 (10)×5–6μ.—Specimen typicum A. H. Smith n. 970, legit prope Boreas River, New York, Sept. 19, 1934; in Herb. Univ. of Mich. conservatum.

Pileus 3–7 cm. broad, obtuse with an inrolled margin at first, expanding to umbonate, campanulate or broadly convex, sometimes nearly plane, the margin sometimes lacerated and recurved in age, surface smooth, moist and glabrous except for a few scattered fibrils along the margin, color "walnut brown" to "Mars brown" (dull testaceous to dark brown), hygrophanous and fading to an ashy cinnamon brown; flesh thin and fairly brittle, concolorous with surface or paler when faded; taste slightly and somewhat fruity or spicy, odor very strong and distinctive, sharp but sweet and somewhat fruity (but totally different from that of *C. pyriodorus*); lamellae dark dull violaceous when young, very dark rusty brown in age, subdistant, narrow to moderately broad, intervenose; stipe 2–7 cm. long, 4–8 mm. at apex, clavate to nearly equal, solid, flesh violet in apex, pallid to brownish progressively downward, surface pallid wood brown from appressed fibrils, becoming dull brown over all in age, cortina scanty and pallid.

Spores 8–9 (10)×5–6μ, ellipsoid, roughened, dull rusty brown under the microscope; basidia four-spored, dull brown in KOH; pleuro- and cheilocystidia none, gill trama parallel, rusty brown in KOH; pileus trama rusty brown in KOH, the surface region composed of compactly arranged greatly enlarged hyphal cells (10–30×18–60μ).

Gregarious under conifers along the Boreas River, New York, Sept. 19, 1934 (970) and Bear Island, Lake Timagami, Ont., coll. Miss. Biggs, Sept. 4, 1936 (Smith 4524).

Observations: The odor of this species is very distinctive and pronounced but difficult to describe. The violaceous colors in the gills and the apex of the stipe are dark and dull. They could not be matched in Ridgway. The species is apparently closely related to *C. privignus* Fr. *C. Brosselini* Joachim (1938) is a much smaller Cortinarius with larger spores. It has a fragrant odor and apparently somewhat similar colors.

Cortinarius cacao-color sp. nov.

Plate 10

Pileus 5–10 cm. latus, obtusus dein convexus vel subplanus, glaber et udus, umbrino-testaceus dein pallide testaceus et furfuraceus, hygrophanus; lamellae testaceae, latae, adnatae, subdistantes; stipes 8–15 cm. longus, 1–2 cm. crassus, aequalis vel ventricosus et deorsum attenuatus, umbrino-testaceus, sericeus; sporae 7–8×5–6.5μ.—Specimen typicum A. H. Smith n. 17,194, legit prope Mt. Angeles, Olympic Mts. Wash. Sept. 24, 1941: In Herb. Univ. of Mich. conservatum.

Pileus 5–10 cm. broad, obtuse to nearly convex when young, the margin incurved, becoming broadly umbonate with a decurved margin, glabrous when young, moist and hygrophanous, variegated between dark and pale "sorghum brown" (dark to pale reddish cocoa-brown), variously streaked when fading, "fawn color" to "army brown" faded and then the cuticle breaking up into minute, lacerate, fibrillose scales or merely becoming furfuraceous over all, the margin always somewhat fibrillose-tomentose; flesh thick on the disc (15 mm.) tapered abruptly away from the stipe and hence thin and fragile for the most part, watery and concolorous with surface when either moist or faded (but with a little less red than in "fawn color"), odor faint but sharp and soon vanishing, taste more or less mild; lamellae "cameo brown" young, "walnut brown" in age, hardly changing color (dark cocoa-color), broad, at times up to 15 mm., adnate but becoming slightly adnexed, subdistant, 41–44 reach the stipe, 2–3 tiers of lamellulae, edges becoming eroded; stipe 8–15 cm. long, 1–2 cm. thick at apex, subfusiform and up to 3.5 cm. thick in the midportion and tapered to an almost rooting base, sometimes equal or nearly so, solid, fleshy, concolorous with pileus but at first hoary from appressed silky fibrils and appearing pallid, with a very thin evanescent apical fibrillose zone from the cortina, the fibrils a very dull vinaceous gray, apex silky, the stipe and margin of the pileus almost identical in color.

Spores broadly ellipsoid to ovate-pointed, 7–8×5–6.5μ, very dark sordid brown under the microscope, with a large central refractive body, slightly roughened; basidia four-spored, brownish in KOH; gill trama regular, pale brownish in KOH; pileus trama homogeneous, the surface hyphae radially arranged and forming a rather compact layer, brownish in KOH.

Singly to scattered under conifers, Mt. Angeles, Olympics, Wash. Sept. 24, 1941 (17,194-type), Sept. 26 (17,302); Olympic Hot Springs Olympic National Park, Sept. 30 (17,477); Mt. Angeles, Oct. 4 (17,551); Olympic Hot Springs, Oct. 2 (17,568); Sol Duc Falls, Olympic National Park, Oct. 6 (17,605); Olympic Hot Springs, Oct. 8 (17,718); Mt. Angeles, Olympic Mts., Wash. Oct. 20, 1941 (18,070).

Observations: *C. cacao-color* is practically identical in stature and color with *C. privignus* Fr. sensu Kauffman. The important difference between

PLATE 10.—*Cortinarius cacao-color* Smith, ×1.

them is in spore size and shape. During the season of 1941 one collection, no. 18,005, of the latter was found. The pilei measured 10–15 cm. broad, the spores 8–10×5–6μ, the stipes 10 cm. long and 3 cm. thick at the apex. Their odor was not pronounced. No matter how carefully the fruiting

bodies are dried, they darken and become fuscous to blackish over the surface of the pileus and stipe. The same is true for all of my collections of *C. cacao-color*. The micaceous or silky appearance of *C. privignus* as described by Kauffman is caused by the loosening of the fibrils forming the cuticle of the cap as the latter fades. In *C. cacao-color* this change progresses to the point of causing the pileus to appear finely fibrillose scaly or furfuraceous. This condition is an important macroscopic character for both species. There is also a difference in the color of the cortina between these two, but the veil is so evanescent that the character is little help in identification. *C. rubricosus* Fr. apparently is also somewhat similar in appearance but is never described as becoming furfuraceous. *C. saturninus* Fr. sensu Henry (1938a) is described as becoming furfuraceous but it has grayish violet gills and large spores (11–12×6.5μ). Since Kauffman's concept of *C. privignus* did not include an appreciable odor and taste, it may represent a distinct American variety of the species.

Cortinarius fuscodiscus sp. nov.

Pileus 1.5–4 cm. latus, conicus vel campanulatus, striatus, glaber, ad discum umbrinus, ad marginem subalutaceus, hygrophanus; lamellae alutaceae, confertae vel subdistantes, angustae, subarcuatae; stipes 6–9 cm. longus, 3–5 mm. crassus, aequalis, sericeo-fibrillosus, pallide brunneus; sporae 8–10×5–6μ.—Specimen typicum A. H. Smith n. 17,589, legit prope Sol Duc Falls, Olympic National Park, Wash. Oct. 6, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1.5–4 cm. broad, conic with the margin either straight or bent in slightly, becoming campanulate or the margin spreading and the disc with a sharp conic umbo, the margin frequently splitting, surface moist and hygrophanous, faintly translucent striate fresh but opaque when faded, "bister" on the disc and "snuff brown" toward the margin (dark dull yellowish brown), fading to "wood brown" at least on the margin (dark avellaneous), the disc remaining dark; flesh thin except in the umbo, dark watery brown, fragile, odor and taste none; lamellae "clay color" (alutaceous) young, dull pale ochraceous tawny at maturity, close to subdistant, 26–32 reach the stipe, 2 tiers of lamellulae, narrow (3–3.5 mm.), tapered toward the margin, subarcuate to depressed-adnate; stipe 6–9 cm. long, 3–5 mm. thick at apex, equal or slightly larger below, pallid brownish within, surface with a thin coating of appressed fibrils, glabrescent, pallid at first from the fibrils, sordid fuscous brown in the basal portion and over all in age, cortina white and scanty, no universal veil remnants present at any stage.

Spores 8–10×5–6μ, broadly ellipsoid, ochraceous tawny under the microscope, roughened; basidia four-spored; gill trama somewhat interwoven, somewhat cocoa-colored in KOH; pileus trama with a surface layer

of enlarged hyphae, the cells 9–25μ in dia. and 10–60μ long, narrow binding hyphae quite numerous, the remainder of the trama cocoa-brown in KOH.

Observations: This species appears to be quite close to *C. acutoides* Pk., but differs in lacking chestnut colors and in having a fuscescent stipe. *C. nigricans* Vel. differs in its spore characters. Two collections from a sphagnum bog on Mt. Baker, Wash. appear to belong in *C. acutoides*. The notes from no. 16,721 are as follows: Pileus "russet" over all at first, gradually fading to near tawny, Lamellae "ochraceous tawny" at first and "tawny" in age. Stipe 9–13 cm. long (growing in sphagnum), 2.5–3 mm. thick above, pallid from a thin coating of fibrils, brownish but not fuscescent within. Spores 8–10.5×5–6μ. The specimens of *C. fuscodiscus* are much darker when dried than those of *C. acutoides*. *C. finitimus* Britz. appears to be close but is described as having spores 6–7×2.3μ.

Cortinarius subacutus sp. nov.

Pileus 1–2 cm. latus, conicus dein campanulatus vel umbonatus, glaber, hygrophanus, subtestaceus vel ad discum subniger; lamellae subtestaceae vel purpureo-tinctae, confertae, angustae, adnatae vel subdecurrentes; stipes 3–6 cm. longus, 2.5–3.5 mm. crassus, aequalis, griseo-fibrillosus, deorsum lutescens; sporae 7–9×4–5μ.—Specimen typicum A. H. Smith n. 17,360; legit prope Mt. Angeles, Olympic Mts. Wash. Sept. 28, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1–2 cm. broad, conic with an appressed margin when young, becoming conic campanulate to expanded umbonate, the umbo conic, glabrous, the margin opaque when moist, "Verona brown" over all at first (very deep brown with a tinge of vinaceous), the disc blackish in some, hygrophanous and fading to near "avellaneous" or more sordid, appearing appressed fibrillose part way to disc when faded; flesh thick under the umbo, abruptly thinner toward the margin, dark "Verona brown" moist, sordid "cinnamon-buff" faded, odor and taste not distinctive; lamellae "Hay's brown" to "sorghum brown" (deep purplish brown), becoming dull cinnamon brown, close, 28–30 reach the stipe, 2 tiers of lamellulae, moderately narrow, 2.5 mm. ±, adnate to subdecurrent, tapered to the margin, edges even; stipe 3–6 cm. long, 2.5–3.5 mm. thick above, equal or slightly narrowed below, becoming hollow, surface appressed fibrillose and pale sordid grayish brown up to the apex or apical region even paler, becoming sordid yellowish below in age, no universal veil remnants present.

Spores 7–9×4–5μ, narrowly inequilateral, dull rusty under the microscope, slightly roughened; basidia four-spored; pleuro- and cheilocystidia not seen; gill trama deep rusty-vinaceous when revived in KOH, incrusting plates of pigment small but conspicuous; pileus trama dark fuscous to vinaceous-fuscous in KOH, incrusting plates of pigment readily visible,

the cuticle scarcely differentiated from the tramal body, both of somewhat enlarged cells.

Gregarious under conifers, Mt. Angeles, Olympics, Wash. Sept. 28, 1941, Stuntz and Smith no. 17,360.

Observations: This species is similar in many respects to *C. germanus* sensu Kauffman, but is readily distinguished by the narrow inequilateral spores as well as lacking the conspicuous vinaceous shades in the pileus described by Kauffman for *C. germanus*. *C. Romagnesii* differs in having pallid gills and larger spores. *C. fistularis* Britz. also appears to be quite similar but its stipe is said to be concolorous with the pileus, hence dark reddish brown and not lutescent. Its gills are described as distant instead of close but they are apparently about the same color in both species. The gills of *C. subacutus* have a very distinctive color, and the vinaceous-fuscous color of the pileus and gill trama, when mounted in KOH, aids greatly in identifying dried material. The very deep purplish brown gills and hygrophanous pileus distinguish *C. subacutus* from *C. castanellus* Pk.

CORTINARIUS CYPRIACUS Fr. Episcrisis Syst. Myc., p. 307. 1838.

Pileus 4–8 cm. broad, with a sharp conic umbo and an inrolled margin when young, broadly campanulate to expanded umbonate in age, umbo sometimes obsolete, the margin often arched, glabrous except for a faint grayish fibrillose fringe along the margin from the cortina, hygrophanous, near "Seal brown" (dark purplish umber) moist, fading to a darker grayish brown, becoming "wood brown" or drab, not striate but often splitting radially in age; flesh 2–3 mm. thick away from the disc, tapered gradually, scissile, watery purplish umber, fading to dark avellaneous, odor and taste slightly but distinctly raphanoid; lamellae "purple-drab" (dull purplish) young, "Rood's brown" to "Vandyke brown" at maturity (dark testaceous), distant to subdistant, 25–30 reach the stipe, 2 tiers of lamellulae, bluntly adnate, very broad (10–15 mm.), edges even; stipe 7–9 cm. long. 8–12 mm. thick at apex, slightly enlarged downward and then tapered to the tip of the base, solid, the apex dull purplish (like the gills), also purplish in the cortex, duller in the central portion, surface purplish gray above, base sordid purplish brown, thinly fibrillose from grayish fibrils, cortina scanty and grayish, sometimes leaving a faint apical zone, with a matted sordid purplish mycelium around the base.

Spores 8–10×5–6.5μ, broadly ellipsoid, roughened, fuscous brown in KOH; basidia four-spored, content pale fuscous brown in KOH; pleuro- and cheilocystidia not seen; gill trama regular, walls with an incrusted fuscous brown pigment; pileus trama with the cells of the upper region slightly enlarged, all with dull fuscous brown incrusting pigment.

Gregarious under spruce, Forks, Wash. June 18, 1939 (14,425).

Observations: This species is very similar to *C. adustus* in appearance, but lacks a universal veil and no purplish tints were noticed in the trama of the gills or pileus when mounts were made in KOH. Quélet (1873) and Ricken very appropriately compared *C. cypriacus* to *C. impennis*. The similarity is striking. In several characters collection 14,425 differs somewhat from *C. cypriacus* as described in most European manuals. There is a matted sordid purple mycelium around the base of the stipe, the gills are more distant, and the spores slightly smaller. In fact my collection appears to be intermediate between *C. saturninus* and *C. cypriacus* sensu Ricken. *C. saturninus* Fr. sensu Henry (1938a) differs in its more convex pileus, the presence of clusters of cheilocystidia on the gills, slightly larger spores and habitat. Henry has given the name *C. subsaturninus* to the species Kauffman recognized as *C. saturninus*.

CORTINARIUS FASCIATUS Fr. sensu Lange, Flora Agaricina Danica 3: 50. Pl. 104. fig. D. 1938.

Pileus 10–20 mm. broad, sharply conic to cuspidate young, becoming conic campanulate to nearly plane but retaining a sharp conic umbo, surface glabrous or with a few fibrils along the margin from the cortina, glabrous and hygrophanous, color "auburn" (dull chestnut brown) over all, the margin translucent-striate, fading to "clay color" (sordid yellowish brown but pale); flesh thin, concolor with pileus, odor none, taste not recorded; lamellae "auburn" when young, becoming paler and near ochraceous tawny at maturity (paler and more yellowish), rather broad (2.5 mm.), ascending adnate to hooked, close to subdistant, edges even; stipe 2–3 cm. long, 1.5–3 mm. thick, equal, with a few scattered fibrils from the cortina but soon glabrescent, concolorous with the pileus (dull chestnut brown) or apex paler.

Spores 7–9(10)×4.5–5μ, slightly inequilateral, pale yellowish brown under the microscope, roughened; basidia four-spored, purplish-fuscous in KOH; gill trama of enlarged cells the walls with purplish fuscous incrusting pigment; pileus trama homogeneous, all cells greatly enlarged, their walls with a purplish fuscous incrusting pigment (when revived in KOH).

Gregarious to subcespitose on soil in the trail up Mt. Angeles, Olympic Mts. Wash. Sept. 29, 1941 (17,432).

Observations: This species appears merely unpolished when faded instead of distinctly fibrillose as in *C. acutus* and has much darker colors in all parts. The two are very easily distinguished in the herbarium by the color of the gill and pileus trama when revived in KOH.

CORTINARIUS IRREGULARIS Fr., Epicrisis Syst. Myc., p. 310. 1836.

Pileus 4–10 cm. broad, obtuse to convex, in age umbonate to plane, the

margin inrolled at first, the disc slightly depressed in some, surface with patches of grayish fibrils near the margin, moist but opaque, hygrophanous, evenly "liver brown" (deep reddish brown) young, fading slowly to "Kaiser brown" (deep ferruginous); flesh thick on disc (1–2 cm.), tapered abruptly near the margin, dark watery brown moist, dull buff when faded, odor none, taste mild; lamellae "avellaneous" or a bit duller and darker when young, becoming "cinnamon-brown" at maturity, broad (10–12 mm.), adnexed, relatively close, 3 tiers of lamellulae, edges even; stipe 4–6 cm. long, 10–15 mm. thick at apex, equal or slightly enlarged upward, solid and dull watery brown within, fading to a paler brownish buff, surface with a thin fibrillose coating, soon glabrous, silky at apex, dull watery brown but with pallid streaks.

Spores 8–10×4.5–5.5μ, subellipsoid (slightly inequilateral) ochraceous tawny under the microscope; basidia four-spored; gill trama regular, pallid brownish in KOH; pileus trama homogeneous, pale sordid brown in KOH.

Gregarious under spruce, near Payette Lakes, Idaho, Aug. 6, 1941 (16,035).

Observations: This species can be distinguished from *C. glabrellus* Kauff. by its larger spores and habitat under conifers. The dark ferruginous pilei are in strong contrast to the color of the young gills. It appears to be close to *C. duracinus* sensu Rea but differs markedly in the characters of its stipe. *Hydrocybe pateriformis* (Fr.) Ricken is also close but is characterized by deep saffron yellow gills and smaller spores. *H. tortuosa* (Fr.) Ricken is a smaller fungus with lilac tints in the apex of the stipe. It is supposed to have gills which stain red when bruised, but Ricken had not observed such a change. *C. irregularis* is said to have a reddish or brick red stipe (beneath the fibrils). My material differed in this respect, but the remainder of the characters appear to place it here. Ricken describes the habitat as in dry mountain conifer forests, a very appropriate description of the habitat of the Idaho collection.

CORTINARIUS PULCHER Pk., Ann. Rep. N. Y. State Mus. **26:** 63. 1874.

Hydrocybe nana Killerman, Denkschrift. Bayer. Bot. Ges. Regensburg, Neue Folge, **18:** 67. 1928.

Pileus 10–15 mm. broad, sharply conic campanulate young, plane with a sharp conic umbo in age, the margin exceeding the gills and connivent to the stipe at first, surface glabrous, polished and lubricous but lacking a gelatinous pellicle, translucent striate, evenly "tawny" to "ochraceous tawny" or the margin a little paler, hygrophanous and fading to pale ochraceous; flesh thickish in the umbo, elsewhere membranous, yellowish brown and watery, odor and taste not distinctive; lamellae "ochraceous tawny" or with a more rusty cast in age, close, 21–24 reach the stipe, 1–2 tiers of lamellulae, broad (3 mm. ±), tapered to the margin, bluntly adnate

but readily seceding; stipe short, 3–3.5 cm. long, 2–2.5 mm. thick, equal, solid, fragile, concolorous with pileus, at first with a faint superior evanescent fibrillose zone from the remains of the thin white cortina, soon entirely glabrous and polished.

Spores 6–7.5×4–4.5μ, very slightly roughened, ellipsoid, rusty brown under the microscope; basidia four-spored, pale rusty brown in KOH; pleuro- and cheilocystidia none seen; gill trama parallel or nearly so, rusty brown in KOH; pileus trama also rusty in KOH; made up almost entirely of inflated cells.

Gregarious under brush, Mt. Angeles, Olympics, Wash. Oct. 10, 1941 (17,757).

Observations: The lack of cheilocystidia distinguished this species from the various members of Naucoria and Galerina as well as certain small Cortinarii. *C. Junghuni* appears to be closest but most authors describe its stipe as thicker, and Rea indicates that its cap is quite reddish. Lange described *C. Junghuni* as having cheilocystidia and lacking striations on the pileus. My material has narrower spores than indicated by Ricken in addition to a polished glabrous pileus. *C. pulcher* appears to be closest to *C. acutus* but the latter is distinguished by its larger spores and silkier pileus when faded. Kauffman (1932) excluded *C. pulcher* on the basis that it probably belonged in the genus Naucoria. My sections of the type did not show cheilocystidia and the spores were typical of Cortinarius. The sections were revived in Lactophenol. The color of the stipe as described by Peck is "whitish or pale ochraceous." However, this discrepancy does not appear significant. The stipe may appear whitish at first from the remains of the cortina.

Hydrocybe nana Killerman apparently is very similar if not identical with Peck's species. It is described as having a reddish brown cap and a weak odor whereas Peck's species is said to be ochraceous and become pale ochraceous and no odor is mentioned. Killerman referred to Saccardo (1894) pl. no. 31 as representing the color of *H. nana*. When this is compared with "tawny" of Ridgway, it becomes apparent at once that the colors of Killerman's specimens and my collection instead of being different are strikingly similar. It is impossible to make an accurate interpretation of Peck's use of the term ochraceous, but we can make a comparison. Peck described *C. sphaerosporus* in the same article, and stated that its cap was pale ochraceous. By Ridgway's system this is somewhere between "straw yellow" and "antimony yellow" and very close to the faded colors of my specimens. The term ochraceous as commonly used refers to a yellower color than ochraceous tawny but the difference in this instance hardly appears sufficient to justify recognizing a species with it as the deciding character. It appears much more likely that Killerman's material was not faded when collected and that Peck's was at least partly faded.

LITERATURE CITED

BRESADOLA, J. 1929. Iconographia Mycologica, **12.** Milano.

BRITZELMAYR, M. 1899. Revision der Diagnosen zu den von M. Britzelmayr aufgestellten *Hymenomyceten*-Arten. Bot. Cent.-Bl. **80:** 57–66.

FRIES, ELIAS. 1821. Systema Mycologicum, **1.** Lundae.

———. 1874. Hymenomycetes Europaei. Upsalia.

———. 1877. Icones Selectae Hymenomycetum nondum Delineatorum, **2.** Upsalia.

HENRY, R. 1934. *Cortinarius (Telamonia) hemitrichus* (Pers.). Bull. Soc. Myc. Fr. **50:** 85–89.

———. 1935. Étude de quelques Cortinaires du Groupe des Scauri. Deux espèces nouvelles. Bull. Soc. Myc. Fr. **51:** 34–101.

———. 1936. Révision de quelques Phlegmacia appartenant aux groupes des Cliduchi et des Elastici. Bull. Soc. Myc. Fr. **52:** 279–299.

———. 1937. Révision de quelques Cortinaires (suite). Bull. Soc. Myc. Fr. **53:** 49–80.

———. 1938a. Révision des Cortinaires (suite). Bull. Soc. Myc. Fr. **54:** 29–43.

———. 1938b. Étude de quelques Telamonias. Bull. Soc. Myc. Fr. **54:** 89–110.

———. 1938c. Suite à l'étude des Myxacia. Bull. Soc. Myc. Fr. **54:** 226–244.

———. 1939. Suite et complément à l'étude des Phlegmacia. **55:** 166–195.

JOACHIM, L. 1938. Note sur quelques apports intéressants faits à l'herbier Mycologique. Bull. Soc. Myc. Fr. **54:** 19–27 (3rd pt.).

KAUFFMAN, C. H. 1918. The Agaricaceae of Michigan. Lansing, Mich.

———. 1921. The mycological flora of the higher Rockies of Colorado. Papers Mich. Acad. Sci. **1:** 101–150.

———. 1932. Cortinarius. North Amer. Flora **10:** 282–348.

KAUFFMAN, C. H. AND ALEXANDER H. SMITH. 1933. Agarics collected in the vicinity of Rock River, Michigan, in 1929. Papers Mich. Acad. Sci. **17:** 153–200.

KILLERMANN, V. SEB. 1928. Pilze aus Bayern, III. Cortinarius, Paxillus. Denkschr. Bayer. Bot. Ges. Regensburg **17,** N. F. **11:** 1–78.

KONRAD, P. ET A. MAUBLANC. 1924–32. Icones Selectae Fungorum, **2.** Paul Lechevalier, Paris.

LANGE, JAKOB E. 1938. Flora Agaricina Danica, **3.** Copenhagen.

QUÉLET, L. 1873. Les Champignons du Jura et des Vosges. Supp. 2.

REA, CARLETON. 1922. British Basidiomycetae. Cambridge.

———. 1926. Appendix to "British Basidiomycetae," additions and corrections. Trans. Brit. Myc. Soc. **12:** 205–230.

RICKEN, A. 1915. Die Blätterpilze. Leipzig.

SACCARDO, P. A. 1894. Chromataxia seu nomenclator colorum. (Editio altera). Patavii.

SINGER, ROLF. 1937. Notes sur quelques Basidiomycètes, III. Rev. Mycologie **2:** 226–242.

SMITH, ALEXANDER H. 1939. Studies in the genus Cortinarius, I. Contr. Univ. of Mich. Herbarium **2:** 42 pp., 12 pls.

———. 1942. New and Unusual Cortinarii from Michigan, with a key to the North American species of subgenus Bulbopodium. Bull. Torrey Bot. Club **69:** 44–64.

SMITH, ALEXANDER H. AND L. E. WEHMEYER. 1936. Contributions to a study of the fungous flora of Nova Scotia, II. Agaricaceae and Boletaceae. Papers Mich. Acad. Sci. **21:** 163–197.

Vanilla: Its History, Cultivation and Importance

DONOVAN S. CORRELL*

(Division of Plant Exploration and Introduction, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture)

The most important and famous flavoring substance, or spice, which the Americas have contributed to the world is vanilla. This is, today, the favorite flavoring material in the United States, where normally about one million pounds of vanilla beans are consumed annually. Since vanilla is a tropical crop, the United States is entirely dependent upon other regions for this natural product. Climatic and edaphic conditions in Puerto Rico, however, are congenial to the vanilla plant, and experience there has shown that the island is potentially capable of supplying most, if not all, of this essential flavoring substance for our domestic needs.

THE PRODUCT AND ITS SOURCE

Vanilla is obtained primarily from the fully grown, but unripened, fruits of a climbing orchid, *Vanilla planifolia* Andrews (*V. fragrans* (Salisb.) Ames), which have been subjected to a fermentation-curing process to produce the characteristic aroma which makes this flavoring so valuable. The finished product is an extract from vanilla fruits (beans), blended with alcohol, pure water, some glycerin and, in some cases, sugar.

The substance chiefly responsible for the peculiar fragrance and flavor of the vanilla bean is *vanillin* ($C_8H_8O_3$). This was first isolated from vanilla by Gobley in 1858. He found that the so-called "givre" of vanilla was due to vanillin crystals and not to benzoic acid as was then believed to be the case (5). Vanillin is a relatively simple substance which has been synthesized on a commercial scale from coniferin, eugenol and other sources. The cured vanilla beans, however, have an aroma and flavor not fully duplicated in synthetic vanillin, and the occurrence of other subsidiary substances, including at least one strongly aromatic ester (16), is the decisive factor in favor of the use of natural vanilla as a flavoring.

Free vanillin is not present in the beans when they are harvested. It is developed as a result of enzyme action on several glucosides, either during the natural ripening of the beans on the vines, or by a curing process. White needle-shaped crystals of vanillin accumulate on the outside of the beans when they are stored in bundles after curing. The crystals are 0.5 to 1 cm. in length. Additional vanillin occurs dissolved in a dark brown oleo-resinous secretion surrounding the seeds in the center of the bean (16). The vanillin content of the beans has been found to vary according

* On leave from Harvard University.

to where they are grown, from 1.5% in Mexico to 2.7% in Java. First quality Bourbon beans contain about 2.3% vanillin.

The percentage of vanillin content, however is not necessarily proportional to the quality of the beans and does not determine their ultimate value, nor are the most strongly aromatic beans always those with the highest vanillin content. As noted above, the subsidiary substances inherent in the fruit influence greatly the aroma of vanilla. Besides vanillin, the beans are known to contain vanillic acid, which is odorless, about 11% of a fixed oil, 2.3% of a soft resin, sugar, gum and oxalate of lime (7), as well as some wax, fat, coloring matter and mineral constituents. The composition of vanilla is not yet completely understood, vanillin being the only constituent whose chemistry has been thoroughly investigated.

Vanilla is a tropical genus of the family Orchidaceae. About fifty species have been described, only three of which (*V. planifolia* Andrews, *V. pompona* Schiede and *V. tahitensis* J. W. Moore) are of commercial importance as sources of vanilla. With the exception of those orchids grown and sold in the floral industry for the beauty and singularity of their flowers, these species of *Vanilla* are the only orchids of any real economic importance.

Vanilla planifolia, the principal source of vanilla, is a coarse vine that, in nature, climbs to the top of tall trees. The plant may be briefly described as follows: Stem simple or branched, long, flexuous, succulent, green, producing opposite the leaves twining adventitious aerial roots by which it clings to trees and other supports; leaves succulent, nearly sessile, oblong-elliptic to narrowly lanceolate, acute to acuminate, 9 to 23 cm. long, 2 to 8 cm. wide; racemes axillary, consisting of as many as twenty or more flowers which are greenish yellow and inconspicuous; flowers composed of three sepals, three petals and a central organ known as the column (the united stamen and pistil), with one of the petals modified and enlarged to form the lip; sepals and petals almost linear to oblong-oblanceolate, obtuse to subacute, 4 to 7 cm. long, 1 to 1.5 cm. wide; lip trumpet-shaped, attached almost to the apex of the column which it envelops, somewhat 3-lobed above, 4 to 5 cm. long, 1.5 to 3 cm. wide at the widest point, with longitudinal verrucose lines or papillae on the disc and a tuft of hairs about the middle of the disc, retuse at the apex and irregularly fringed on the revolute margin; column hairy on the inner surface, about 3 cm. long; fruit a capsule (commercially known as a "bean"), narrowly cylindrical, 1 to 2.5 dm. long, 8 to 14 mm. in diameter.

This species, the true vanilla of commerce, is now thought to be indigenous to southeastern Mexico, Guatemala, British Honduras, Honduras, Nicaragua, Costa Rica, El Salvador, Panama, the West Indies, Colombia, Venezuela, Surinam, British Guiana, French Guiana, Ecuador, Peru and Bolivia. It occurs as a non-persistent waif in Florida and prob-

ably in most of the tropics and subtropics of the world. It is widely cultivated.

Vanilla pompona is a less important source of natural vanilla. It is known as vanillon, South American, West Indian or pompona vanilla and produces shorter, thicker beans. It resembles *V. planifolia* except that its leaves are larger, being 15 to 28 cm. long and 4 to 11.5 cm. wide. The green-yellow flowers are larger and more fleshy, and the lip has a tuft of imbricating scales, instead of hairs, in the center of the disc. The beans are cylindrical and more fleshy-thickened, being 15 to 17.5 cm. long and 2.5 to 3.3 cm. in diameter. They are inferior in quality and, consequently, command a lower price.

This species is indigenous to southeastern Mexico, Central America, Trinidad and northern South America. It is cultivated primarily in Guadeloupe, Dominica and Martinique. Attempts to cultivate it have been made in other parts of the world, but little is known regarding the results.

Vanilla tahitensis, the Tahiti Vanilla, differs from *V. planifolia* in having more slender stems, narrower leaves, longer perianth segments, a lip that is shorter than the sepals and shorter pods. The reddish-brown beans are 12 to 14 cm. long, up to 9 mm. in width, broad in the middle and tapering toward either end.

This species is indigenous to Tahiti. It is cultivated there and in Hawaii.

Several other species of Vanilla, concerning which there is little information available, have possibilities of producing vanilla for commerce. According to Rolfe (15), Gardner commented in collecting *V. Gardneri* Rolfe, "This is the plant which yields the Vanilla (Banilha of the Brazilians) in Brazil." This species is thought to be the source, to some extent, of what is known in commerce as "South American Vanilla."

The fruits of *V. appendiculata* Rolfe, from British Guiana, are said to retain a distinct aromatic odor for twenty-five years or more after having been collected (15), and the beans of *V. phaeantha* Reichb. f., which has been cultivated in some places in the West Indies, possesses some perfume. Presl, in describing *V. odorata*, from northern South America, noted that although the fruits had been collected thirty-six years previously, they still retained their aromatic fragrance. Rio vanilla, said to be obtained from *V. palmarum* Lindl., in the province of Rio de Janeiro, Brazil, and Guiana vanilla, said to be obtained from *V. guianensis* Splitgerber, are, at most, products of inferior quality. It is quite possible that these poorly known and apparently less valuable vanillas are used as adulterants of the true Mexican vanilla, *V. planifolia*. The vanillon, *V. pompona*, is commonly used for this purpose. In Mexico, the Indians are said to eat the fruits of a wild vanilla, known to them as "vanilla plátano," which is reported to be a smaller plant with larger leaves than *V. planifolia* (6). The botanical identity of this plant is unknown.

HISTORY AND DISTRIBUTION

The history of vanilla is replete with adventure and romance. Bernal Diaz, a Spanish officer under Cortez, was perhaps the first white man to take note of this spice when he observed Montezuma, the intrepid Aztec emperor, drink "Chocolatl," a drink prepared from the pulverized seeds of the cacao tree, flavored with ground vanilla beans, which the Aztecs call "tlilxochitl," derived from *tlilli*, meaning "black" and *xochitl*, interpreted here as meaning "pod."* Vanilla beans were considered to be among the rarer tributes paid to the Aztec emperor by his subject tribes. Cortez was subsequently introduced by Montezuma to his first cup of chocolate, served according to legend in golden goblets, with spoons of the same metal; but the Aztecs jealously guarded their secret—the flavoring principle of the drink. After the vanilla ingredient was finally discovered the Spaniards imported vanilla beans into Spain about 1510, where factories were established as early as the second half of the sixteenth century for the manufacture of chocolate, flavored with vanilla. Thus, vanilla may be considered a by-product of the Spanish Conquistadors' search for the hidden wealth of the Americas; a by-product which is today one of the most important of the minor extractive industries in Mexico.

Bernardino de Sahagun, a Franciscan friar, who arrived in Mexico in 1529, was perhaps the first to write about vanilla when he stated that the Aztecs used "tlilxochitl" in cacao, sweetened with honey, and that they sold vanilla spice in their markets. His work, "Historia General de las Cosas de Nueva España," originally written in the Aztec language, was not published until 1829–30, in Mexico—three hundred years after Sahagun's arrival in that country. The first observation of botanical interest was made by Carolus Clusius, in 1605, in his "Exoticorum Libri Decem," (p. 72), where he described and gave the name *Lobus oblongus aromaticus* to some dried vanilla beans which he had received, in 1602, from Hugh Morgan, apothecary to Queen Elizabeth. These beans were considered to be fruits of *V. planifolia*, the true Mexican vanilla, although nothing seems to have been known of their native country or uses. This same Morgan was the first European to suggest vanilla as a flavoring in its own right, a fact already known to the Aztecs.

In 1571–77, Francisco Hernandez was sent on a mission to Mexico by Philip II, of Spain. While in Mexico, Hernandez became an authority on vanilla and in his work noted above, first published in Rome in 1651, he not only described and named the plant, *Araco aromatico*, but he figured a vanilla branch with leaves and two beans growing upon it (p. 38). He

* In the 1651 edition of Hernandez' work (Rerum Medicarum Novae Hispaniae Thesaurus) this name was correctly interpreted to mean "black flowers." The flowers of this species, however, are greenish yellow in color. This fallacy concerning the color of the vanilla flowers remained in literature for many years.

also recorded its native name as "tlilxochitl" and noted that it was held in high esteem by the Mexicans, not only for its pleasant taste and aroma, but because of its supposed healing qualities. A few years later, in 1658, Willem Piso wrote that, because of their fragrance, the Spaniards used the beans, which they called "vaynilla," meaning "little pod," as an ingredient in the manufacture of chocolate (Historiae Naturalis et Medicae Indiae Orientalis, p. 200). This is supposed to have been the first use of the word "vaynilla," from which the scientific name of the genus is derived. Francesco Redi, in 1675, studied some dried fruits of vanilla under a microscope and described the fruit and seeds (10). William Dampier, in his "A New Voyage Round the World," gave some valuable information about vanilla plants which he had observed growing, in 1676, on the Bay of Campeche, in southern Mexico, and, in 1681, at Boca-toro, in Costa Rica. He stated that the beans were collected by the Indians who sold them to the Spaniards. He also described the method of curing the fruit.

The generic name, Vanilla, was first used in 1703, when Plumier (Nova Plantarum Americanarum Genera, p. 25, pl. 28) enumerated three species from the West Indies, but failed to include the Mexican plant, *V. planifolia*. The genus, Vanilla, was not definitely accepted until 1799 when Swartz distinguished two species, *V. aromatica* and *V. claviculata*.

The nomenclatural status of the vanilla of commerce has never been definitely settled to the satisfaction of all botanists. According to Rolfe (15), the monographer of the genus, "The Mexican *Vanilla* had been introduced to cultivation prior to 1739,* when the second edition of Miller's 'Gardener's Dictionary' was published, but appears to have been again lost. It was, however, re-introduced by the Marquis of Blandford and flowered in the collection of the Right Hon. Charles Greville, at Paddington, prior to 1807, in which year a flowering specimen was figured and described by Salisbury under the name of *Myobroma fragrans* (Parad. Lond., 't. 82), and a year later Andrews published another figure as *Vanilla planifolia* ('Bot. Rep.,' viii. t. 538). Both of these authors wrongly identified the plant with a West Indian species, and both equally failed to recognise in it the true Mexican *Vanilla* of commerce, whose flowers were now figured for the first time."

It is interesting to note that the same plant which flowered in 1807 also produced fruits, at which time Bauer, the famous illustrator, prepared a drawing of the plant showing a fresh fruit. This is the first record of a vanilla fruit having been produced in Europe. How the flower was pollinated and became fertilized is not known.

Among the principal early authors who described vanilla in its native

* The second edition of Miller's "Gardener's Dictionary" was published in 1733.

habitat may be mentioned Fusée Aublet who, in 1775 (Histoire des plantes de la Guiane Françoise 2, Mém. 4, pp. 77–85), not only recorded the methods of cultivation and curing of the fruits, but gave an account of three kinds of vanilla, typified by large, small and long beans, found in the vicinity of Cayenne, French Guiana. Humboldt, in 1811 (Voyage de Humboldt et Bonpland 2, pt. 3, p. 437), also gave an interesting account of the culture and preparation of vanilla in the State of Veracruz, Mexico.

Although Vanilla as an article of commerce was introduced into Europe as early as 1510, it did not appear permanently in horticulture until the beginning of the nineteenth century when, as noted above, in 1807, it gained attention after having flowered and fruited in the collection of Charles Greville.

For more than two centuries Mexico and other regions where *V. planifolia* is indigenous were the only commercial sources of vanilla since only in these regions was it possible to obtain fruits. Because of the unique adaptation of the flowers of orchids to insect pollination, only the bees in the regions where the plant grew naturally were apparently able or inclined to pollinate the flowers effectively. The dependence upon, and lack of, such specific pollinating agents retarded for some time the introduction of the plant as a plantation crop into other regions of the world congenial for its growth.

An effort was made to establish vanilla in Java in 1819 when two plants were dispatched to Buitenzorg from the Botanic Garden at Antwerp. Only one of these plants, however, survived the voyage and subsequently, in 1825, produced flowers, but no fruits. Later, in 1846, vanilla cultivation on a systematic plantation basis was established in Java.

In 1836, Charles Morren, of Liége, established the identity of the true vanilla of commerce as *V. planifolia*, and obtained two large crops of vanilla beans by pollinating the flowers artificially by hand. He attributed the failure of the plants to produce fruit in the eastern hemisphere to the absence of the particular insect or insects which pollinated the vanilla flowers in their native regions. In 1838, Morren's achievement was repeated by Neumann of the Muséum d'Histoire Naturelle in Paris, and several years later, in 1841, a former slave, Edmond Albius, in Réunion, discovered a practical method of artificial pollination which is used to this day.

This discovery of a method of artificially pollinating the flowers of vanilla, combined with the possibility of propagating the plants by cuttings, opened the way for its cultivation as a plantation crop on a large scale in the eastern tropics. Madagascar, which normally produces one half or more of the supply of vanilla beans grown in the world, is the most important area. Vanilla is also grown successfully, to a greater or lesser degree, in Réunion (Bourbon), Mauritius, the Seychelles Islands, Zanzi-

bar, French Congo, Congo Independent State, Cameroons, Sierra Leone, Lagos, San Thomé, Comoro Islands, Ceylon, Java, the Society Islands and the Fiji Islands. It has not been too successful in Hawaii, the Philippine Islands, India, Cochin-China or the Malay Peninsula.

The history of the gradual but universal spread of the vanilla of commerce throughout the tropics of the world is meagre and, for the most part, unreliable. According to Ridley (14), vanilla was first introduced into Réunion in 1793, but its cultivation did not become important until after the sugar cane-failure between 1849 and 1856, and did not attain large proportions until about 1874. From Réunion, the plant was introduced into Mauritius, and, about 1840, into Madagascar.

Vanilla was introduced into India in 1835, but it was allowed to die out after flowering. Some years later it was again brought to India where it produced fruit, but its cultivation has never progressed in that country. Vanilla is said to have been introduced from Manila to the island of Tahiti by Admiral Hamelin in 1848 and it soon developed into a major industry. An unsuccessful attempt was made in 1852 to introduce the plant into the French Congo. It was successfully reintroduced in 1873, but its cultivation has not spread very rapidly. Vanilla growing was started in the Seychelles Islands about 1890, and cultivation in the Comoro Islands was begun in 1893 and very soon spread throughout these islands. By 1886, vanilla production was greater in the Mascarene Islands (Réunion, Mauritius, Rodriguez) and Java than in Mexico (11).

As may be noted from the above, the French, more than any other nation, have developed the vanilla industry in their overseas possessions. Soon after its introduction into Spain, vanilla was replaced by cinnamon as a flavoring for chocolate. In France, however, it remained the favorite and eventually it came to be used in perfumes, confections and ices. In recent years the French Colonies have produced approximately three fourths of the vanilla beans of commerce, and more than 20,000 persons are said to be engaged in this occupation.

Vanilla planifolia is also cultivated extensively in the western tropics, and some wild beans are harvested in regions where the plants are indigenous. Mexico and the French West Indies are important producing areas, and Puerto Rico shows great promise for future expansion of the industry.

According to Mallory *et al.* (11), the Totonoco Indians of Mexico, one of the three tribes who were supposed to grow vanilla for the Aztecs, were among the first to pledge allegience to Cortez and consequently were left undisturbed in the private ownership of their individual tracts. Today vanilla culture in Mexico is carried on almost entirely within their lands. This area lies for the most part on the first rising ground on the coastal plan of the Gulf of Mexico in southeastern Mexico. About 10,000 Indians

in this region are said to produce most of the vanilla exported from Mexico. The skill and thrift of the Totonoco Indian make him a prime factor in the Mexican vanilla industry. He is a good bargainer and demands payment in silver which he may bury in the ground (11). He is also said to control the production of the beans, increasing or reducing his crops with the rise and fall in prices. The beans are generally sold to the larger export houses or to their traveling agents.

The most important vanilleries (vanilla plantations) in Mexico are in the states of Veracruz and Puebla. In Veracruz, the most productive ones are located in the vicinity of Papantla, Misantla and Jalacingo, south of Tuxpán, which is the principal port of embarkation. In Puebla, the vanilleries are located primarily at Tetela and Ocampo. These two states produce about 98% of the vanilla in Mexico. The rich volcanic soils and the climatological factors combine to make this area perhaps the ideal region in the world for vanilla culture. Most of the plantations are at an altitude of about 1,000 feet above sea level.

Other vanilleries of minor importance are found in the states of Chiapas, San Luis Potosi, Oaxaca, Tabasco and Michoacan. In 1920, it was estimated that more than 50,000 persons were employed in Mexico in the cultivation, handling and extraction of vanilla.

In Guatemala, the Indians of Vera Paz are said to collect some wild vanilla in the woods along the banks of the Polochia River, and in the forests northwest of Cobán (7).

USE AND ECONOMIC IMPORTANCE

Vanilla is today one of the world's most important flavoring materials. Since its early advent into Europe about the year 1510 (15), it has competed strongly and successfully with other spices in the world's markets, and as late as 1908 at least three times as much vanilla as all other flavoring materials was said to be consumed annually (13).

Vanilla beans, as mentioned above, were used by the ancient Aztecs of Mexico and Central America for flavoring chocolate long before the arrival of the Spanish conquerors. When first introduced into Europe, vanilla was used primarily as a flavoring for chocolate or as a tobacco perfume. Early explorers of tropical America, however, extolled its medicinal virtues and vanilla soon became an important drug, its reputation as an aphrodisiac being widespread. Belief in the medicinal properties of vanilla was strong during the sixteenth century; as early as the beginning of the seventeenth century it was given a place in the German pharmacopoeia, and in 1721 it had a place in the London Pharmacopoeia (16). The use of vanilla as a medicine waned during the latter part of the eighteenth century, and by the end of the nineteenth century, for all practical purposes, it was eliminated as a drug. It is still used to some extent, however, in

FIGS. 1–4. *Vanilla planifolia*. 1, habit, ×½; 2, lip, in natural position, side-front view, ×1; 3, lip, spread open, ×1; 4, column, side-front view, ×2. Drawn by Gordon W. Dillon.

medicine mainly to flavor otherwise distasteful elixirs and certain medicinal solutions.

It is interesting to note that at the height of its exploitation as a drug, physicians propounded various theories concerning the supposed therapeutic effects of vanilla which today seem ridiculous. One medical flora stated that " . . . vanilla exercises a powerful action on the animal economy, and justifies the attributes of tonic, stimulant, and comforting, which are accorded it. The truly active and strong impression which it makes on the nervous system by its fragrant aroma, and on the stomach when taken internally, is rapidly and sympathetically transmitted to all the organs, the functions of which it more or less accelerates. Hence, when the system is lowered, vanilla facilitates digestion and nutrition, augments the cutaneous transpiration or the secretion of urine, and acts as a tonic in various other ways. It is recommended in cases of dyspepsia, melancholy, hypochondria, and chlorosis, where the digestive functions are sluggish or torpid." (7)

On the continent of Europe, vanilla was also at one time used in hysteria, low fevers, impotency and rheumatism, and was thought to prevent sleep and "increase the energy of the muscular system." It was used by Spanish physicians in America to cure various maladies, being considered a strong stimulant and stomachic, and as an antidote to poison and to the bite of venomous animals (1).

In Mexico, home of the vanilla, very few of the natives who work in the industry are said to taste vanilla, because they have developed the impression that it possesses properties which cause it to act injuriously upon the nervous system (7). In fact, only a very small amount of the natural product is used in Mexico. Instead, artificial vanilla, which costs only a fraction of the price of pure vanilla, is imported for national consumption. This condition is doubtless, at least in part, the result of vanilla being a highly remunerative crop for export and not necessarily because of any antipathy to the bean.

Since vanilla beans yield a fine brown color, they were at one time thought to be a possible source of dye. During the last century the Germans unsuccessfully experimented with the beans for this purpose.

Vanilla is by far the most popular flavor at the present time in the ice cream, baking and chocolate industries of the United States. It is chiefly used as a flavoring of chocolate, beverages, confections, cakes, custards, puddings, ices, ice cream, and in the manufacture of soaps, perfumes and sachet powders. When added to the heavy oriental varieties of perfume, vanilla extract makes the odor more delicate. Vanilla is ordinarily used in the form of an extract from the beans. In the manufacture of chocolate, however, the beans are usually ground finely with sugar and included with the chocolate. One bean is considered sufficient to flavor $1\frac{1}{2}$ pounds of

chocolate. Some chefs still insist on using the bean, itself, in the food to be flavored instead of using the extract. Since the vanilla essence is known to be more volatile at high temperatures, there is perhaps some justification for this rather expensive practice.

The statistical data concerning vanilla are not too satisfactory or reliable, whether they concern the amount of vanilla grown throughout the world, consumed *in situ* or exported, or the proportions utilized in the manufacture of various products. The United States normally imports about four fifths of its vanilla beans from sources outside the western hemisphere, principally from France and its colonies. In 1939, the United States imported more than one million pounds, valued at one and one half million dollars. Three fourths of these imports came from France or directly from Madagascar and other French colonies. In recent years, vanilla beans have been second only to coffee in export value from Madagascar. Mexico, the source of beans of best quality, provided 270,000 pounds. Imports into the United States in 1940 exceeded those of 1939, but since that time the source of supply has been cut off, the importation of vanilla beans has been greatly reduced, and the stock pile of beans has been greatly diminished.

In 1920, Cunningham (6) wrote, "Because of the fact that the United States buys most of the vanilla of Mexico the dollar is the basis of price, both for buying and selling. The price paid at the plantation varies from $2.50 to $3 per pound, while the price in Vera Cruz is about $3.50 per pound. The New York price is about $4.50 per pound, with duty paid. Mexico levies an export duty of 1 peso per kilo plus a surtax of 10 per cent. These have been the ruling prices for 40 years."

However true the above may be, the price of vanilla beans apparently remains in a state of flux, not only in Mexico but also in other regions. In 1900, Mexican beans sold for about $9.00 per pound (13), and in 1939 they sold for approximately $4.00 per pound. Because of its overwhelming production of good quality beans, Madagascar sets the price of this product during normal times. In 1942, Madagascar was said to have had a two years' supply of beans in storage for shipment to foreign markets. As much as $250.00 per pound is supposed to have been paid for vanilla beans at one time (7). There are so many factors which influence prices that they can not be considered a true index of quality.

In 1942, Mallory *et al.* (11) wrote concerning Mexican beans, "In 1941, vanilla returned to its value in the days of the Spanish Conquest when it nearly equaled its weight in silver. In January 1941 it was $9.25 a pound; today it is $16." During the same year Madagascar beans, when obtainable, were selling at $13.00 and $14.00 per pound. In the meantime, the prices have been lowered and stabilized. Today, Mexican, West Indian and Bourbon first quality beans sell for $10.00 and $11.00 per pound in the markets of the United States.

HORTICULTURE

The horticultural technique of growing vanilla is essentially the same wherever the plant is cultivated. The usual procedure is to select a suitable location, clear the land of all trees and shrubs except such as may be desirable supports for the vanilla plants to climb upon, prepare the soil, plant or erect mechanical supports for the plants to grow upon, plant shade trees and arrange a wind-break if this is necessary, obtain and plant the vanilla cuttings, train the plants over the supports used, keep the vines and living supports properly trimmed, watch for parasites and destructive diseases, see that the flowers are correctly pollinated at the right time, select and retain only the desired number of fruits to be allowed to mature, and finally harvest the crop which then has to be cured. A great amount of individual attention has to be given the plants. Consequently, this will limit the size of the plantation which can be maintained at a highly productive and profitable level. Since vanilla is a crop that requires constant attention, everything possible should be done to facilitate the work. If the plantation is at the start planned and set out in an orderly manner many unnecessary future expenses, as well as loss of time and labor, will be avoided.

In nature, *V. planifolia* is commonly found climbing on trees in swamps, wet thickets and in mixed forests in low country. It seems to do well from sea level up to about 2,000 feet altitude and may even be found at 3,500 feet in Mexico. To thrive and be most productive, the plant requires a hot, moist tropical climate with frequent but not excessive rains. Arid conditions and violent winds are detrimental to the plant. Like so many other spices, vanilla is most successfully grown on islands or in littoral regions having an island climate, and with the exception of those in Mexico, all of the larger plantings are to be found on islands. A climate like that found in southeastern Mexico, the Mascarene and Seychelles Islands, the West Indies, Tahiti and Fiji has proved to be ideal for the cultivation of vanilla. In these regions the temperature varies from about 70° to 90° Fahrenheit, with an average temperature of about 80°. The annual rainfall is approximately 80 to 100 inches and is more or less evenly distributed throughout the year, with the atmospheric humidity always high. The ideal situation concerning precipitation is to have an even distribution of rainfall through ten months of the year for continuous luxuriant growth of the plants and the production of large fruits, with the remaining two months relatively dry so as to check vegetative growth and bring the vines into flower. Regularity of the proper climate is a most important point to be considered in the cultivation of vanilla, since temperature and humidity, and various other ecological factors, are thought to affect the quality of vanilla—its aroma and potency.

If climatic conditions are suitable for growing vanilla, other factors

which must be considered in developing a vanillery are the terrain and soil. Level land which allowed stagnation of water about the vanilla roots should be avoided. Likewise, too steep a site should not be selected since erosion may seriously affect the plants, and such a location will also add to the difficulty of attending to the plants. If the only available land slopes steeply it should be terraced before the vanillery is planted. The ideal site, as noted above, is a gently sloping hill which allows adequate but not excessive drainage, permits the maintenance of a leaf mulch at all seasons, and will not interfere with the cultivation of the vanillery. Any soil which is light, porous and friable, easily penetrated by the roots of the plant, and abundantly supplied with decaying vegetable matter appears to be suitable for vanilla.

Since the roots of vanilla are mostly confined to the surface or humus layer, it is a good practice to maintain a thick layer of humus. In a test, McClelland (13) found that root development was 85% greater in leaf-mold than in soil. Also, the new vine growth was found to be considerably greater in leaf-mold than in soil. This emphasizes the necessity of keeping the vines continually supplied with a heavy vegetable mulch. In clearing the site all bulky debris should be chopped up and left to decay. This should not be burned over. As is the case with all orchids, animal manures are harmful and should not be used, and since the different vegetative organs of vanilla have been found to contain an exceptional amount of potash and lime, these chemicals should be present (5). The practice of adding burnt earth, lime and vegetable debris to the soil supplements to some extent these chemicals which may already be present. To help prevent erosion and avoid exposing the vanilla roots to the sun and elements, excessive weeding should not be done. Weeds are also an annual source of mulch for the plantation.

When originally developed as a plantation crop, vanilla plants were grown close together with the plants greatly entangled. This intensive culture produced enormous crops and was widely practiced until fungus diseases attacked the vanilleries in Reúnion and other parts of the world. With the vines entwined as they were, it was a hopeless task to extricate the diseased plants from the healthy ones, and many vanilleries were completely wiped out or the plants devitalized to such an extent that they were essentially worthless. Although the yield is less and the cost of maintenance is more per acre, the usual practice today is to place the supports or supporting trees about nine feet apart and grow only one vanilla plant upon each support. In this method there are only 537 vines to the acre and a diseased plant may be easily removed from the vanillery without disturbing the healthy plants. Also, the plantation is easily worked when the plants are grown so far apart. Other methods are to grow the vines five feet apart in rows ten feet apart, giving 871 vines to the acre, or four

feet apart in rows eight feet apart, giving 1,361 vines to the acre (13). These closer plantings give a larger early return, but the close spacing of the plants is inconvenient for the workers and the plants are more susceptible to contagious diseases.

In nature, vanilla grows in forests or shrubby land where it has filtered light or partial shade and a support upon which to climb. These conditions should be simulated in the vanillery for best results. However, instead of allowing the vines to grow to great length as they do in the wild state, they must be trained to grow within easy reach of the workers so that the flowers may be pollinated, the vines pruned and the fruits harvested. Various experiments have shown that vanilla plants grown under a light shade are more healthy and produce a larger mass of sturdy vines than those grown in full sunlight or heavy shade. Heavily shaded vines are typically etiolated and spindly, whereas those grown in direct sunlight are yellowish and often burned.

There is no complete agreement among growers as to which is the best support for the vanilla: a living tree, trellises, lattice-work, posts and wire or bars.

Posts are subject to decay and to the ravages of termites, necessitating their being replaced at frequent intervals. In the case of wire or bar supports the tender succulent vines may be easily broken over so thin a support, especially in a strong wind. Where supports other than small trees are used it is always necessary to supply some form of partial shade for the vanilla plants. This is usually accomplished by planting tall, widely spaced trees or banana plants.

Although the type of support depends somewhat on the region where the vanillery is established, the most satisfactory supports are unquestionably small trees. The selection of the tree to be used depends largely on local conditions. In general, however, small-leaved species which permit checkered sunlight to filter through are considered most desirable. Most growers prefer species which grow rapidly in full sunlight and which produce branches sufficiently low (from five to seven feet from the ground) for the vines to hang within easy reach of the workers. The tree should be strong enough to support the vanilla vine even in a strong wind, and should never become entirely defoliated. It should also be possible to propagate it from large cuttings so that the young tree will grow rapidly from the beginning. If possible the trees should be planted a year or more before the vanilla cuttings are set out so that they will have had sufficient time to produce adequate support for the more rapidly growing vines.

The physic nut, *Jatropha curcas* L., a common and widespread small tree, which may be propagated from cuttings, is used extensively as a vanilla support. It also grows rapidly from seeds. In the Seychelles Islands, *Pandanus hornei* Balf. f. and several species of figs, *Ficus spp.*, are com-

monly used. Some planters in the Seychelles make the soil do double duty by growing vanilla vines on coffee trees. In Mexico, the calabash, *Crescentia cujete* L., and the coral tree, *Erythrina sp.*, are frequently used. The croton-oil plant, *Croton tiglium* L., is used by some growers and is said to be able to withstand winds of hurricane velocity. According to Ridley (14), in the Singapore Botanic Gardens, vanilla was successfully grown on the African oil palm, *Elaeis guineensis* Jacq. This being the case, it may be possible to grow these two tropical crops together since their cultural requirements are similar. In Puerto Rico, bucare, *Erythrina corallodendron* L., and the coral-tree, *E. berteroana* Urban, are well adapted for this purpose and have been widely used. Also, *Bauhinia purpurea* L. and the anatto-tree, *Bixa orellana* L., have been used for supports. Some other trees used in various regions for vanilla supports are the horse-radish tree, *Moringa oleifera* Lam., common screwpine, *Pandanus utilis* Bory, *Dracaena marginata* Lam., dragon's blood, *Dracaena draco* L., yellow mombin, *Spondias mombin* L., coral-tree *Erythrina variegata* Stickm., madura. *Gliricidia sepium* (Jacq.) Kunth, lebbeck-tree, *Albizzia lebbeck* (L). Benth, horsetail-tree, *Casuarina equisetifolia* Stickm., avocado, *Persea ameriana* Mill., India rubber tree, *Ficus elastica* Roxb., cotton tree, *Bombax malabaricum* DC., mango, *Mangifera indica* L., padouk, *Pterocarpus indicus* Willd., *Lagerstroemia floribunda* Jack, jackfruit, *Artocarpus integra* (Thunb.) Skeels, loquat, *Eriobotrya japonica* (Thunb.) Lindl., and cassava, *Manihot esculenta* Crantz. The use of leguminous trees is advisable in that they will help to improve the soil, especially if the land has been depleted by some previous crop.

Although the supporting trees usually provide sufficient protection from sun and wind, they are often inadequate for these purposes before the vines become mature. Tall, quick-growing, wide-spreading varieties of banana are commonly used to provide shade. In Mexico, maize is often grown to shade the young vines. The vines and leaves are succulent and heavy and, if exposed directly to violent winds, they are often badly damaged. If planted on an open hill or along the coast in a region susceptible to strong winds a wind-break of some kind should be planted on the windward side. According to Ridley (14), red hibiscus has been recommended as a hedge for this protection. Any strong, thickly branched, wind-resistant shrub or small tree should be suitable for this purpose.

Although vanilla can be grown from seeds, it is always propagated on plantations by means of cuttings. Various lengths of cuttings are used, the length having a decided influence on the development of the vine. In all cases, the cuttings should be taken from vigorous healthy plants. In Mexico, it is a common practice to use cuttings one foot in length, but cuttings of three or four feet length are often used. In some regions cuttings of six to twelve feet are set out so that the free end may hang over the

support. If possible, long cuttings with twelve to twenty-four internodes should be used. The longer cuttings, if planted at the beginning of the rainy season, maintain a continued growth and bear flowers and fruits in one or two years. The short cuttings do not bear flowers and fruits until the third or fourth year. In the Seychelles Islands, during good growing weather—warm, still and moist—growth is rapid and some plants have been observed to grow as much as an inch a day (8). Experiments have shown that growth made by the shorter cuttings is greater in proportion to that made by the longer cuttings. McClelland (13) found that in a twelve months period cuttings with two internodes grew 4.7 feet, with four internodes 7.7 feet, with eight internodes 10.7 feet, and with twelve internodes 16.7 feet. Nevertheless, since the longer cuttings come into bearing much sooner than do the shorter ones it is more economical and profitable, when material is available, to plant long cuttings.

After the surface of the ground has been leveled around the base of the support and a heavy application of vegetable mulch has been added, several nodes of the cuttings are covered by soil or leaf-mold at the base of the support. At least two nodes are left above ground and this portion is trained to the support by being tied in several places to prevent swinging. If the free end is longer it is hung over the supporting branches and tied. Within several weeks the vine lengthens and sends out adventitious aerial roots which cling to the support. If necessary, cuttings may be started in a nursery and removed to the plantation. It is best, however, to start them in the plantations so as to avoid the possibility of disturbing the roots when the plants are moved. According to McClelland (13), it seems to make little difference whether the cuttings are planted immediately or allowed to wilt for twelve or fifteen days. Sometimes the covered portion of the vine will rot away or become diseased, especially the injured basal tip. It has been observed that if the leaves are left on the cuttings to avoid injury by removal and the basal tip of the vine is left exposed to the air to heal over, the cutting usually escapes rot and diseases. In some regions, as Dominica, the vine is merely laid on the surface of the soil and lightly covered with wilted grass after having been secured with two crotched pegs (13). It is advisable to use this method if rotting is prevalent in the plantation.

Once established, a plantation has to be given constant attention. It should be gone over at least every other week so as to train the vines to grow at a convenient level, prune the growing vines and tree supports, watch for diseased plants and parasites, and to keep a mulch over the surface of the ground, especially over the roots of the plant. Cultivation of the ground is not feasible since the roots grow at or near the surface, and any disturbance of the soil would also disturb the roots of the plant. As long as the vine can climb upwards it will not flower. Hence, the tip

of the vine is cut off about nine or ten months before the flowering season. The flowers are produced in the axils of the leaves on long, hanging branches. When the plants are in flower they need daily attention. The flowers have to be pollinated and the stalk of the inflorescence must be clipped just back of the remaining buds, or the buds, themselves, should be removed after the desired number of pods are set on each infloresence. This prevents the loss of the plant's vitality in the production of useless blossoms, avoids the pollination of too many blossoms, and saves the pollinator from having to examine superfluous flowers. All undesirable pods should also be removed. After flowering and fruiting, the old stems should be trimmed away. These will be replaced the following year with new and more productive stems. According to Ridley (14), heavy pruning of young stems is very productive, but it shortens the productive life of the plant to two or three years. After pruning, shoots will appear farther back and these are left for the next year's crop.

The vines are said to reach their maximum production about the seventh or eighth year and may, if given proper care, continue to produce for several more years. One author gives forty years as the maximum productive life of vanilla, but this seems unlikely. In Mexico, at the end of three years after planting, a small crop is gathered, and for four or five years the vines continue to increase in size and production. At the end of nine or ten years the vines have lost their commercial value and are abandoned.

To prolong the life of the vines, some growers divide their plantations into four equal parts and pollinate the flowers in only one section each year. This method gives smaller returns at first but a constant yield is maintained over a number of years because of the three years rest that each vine has between each crop. This rest period also tends to keep the vines in a vigorous condition and makes them more resistant to diseases.

Except in Mexico and other areas where the species is indigenous, all beans of *V. planifolia* are obtained by means of hand-pollination. In the regions where it is indigenous, *V. planifolia* is said to be pollinated by bees of the genus Melipona and also by humming-birds (14), which visit the fragrant flowers to obtain the honey secreted at the base of the lip. The insect-pollinated flowers, being cross-pollinated, produce seeds which will germinate and produce plants, whereas those flowers which are hand-pollinated, being self-pollinated, produce seeds which are sterile.

Since only a small percentage of beans set naturally, the Mexicans do not depend entirely upon insect-pollination, but also resort to hand-pollination. In this manner they are able to control the production of beans. "It is thought that families of French extraction living in Nautla introduced manual fertilization into Mexico about 1890 or 1895." (11).

Vanilla planifolia normally flowers but once a year, the flowers being

produced in April and May in Mexico and as late as November in some regions. In Guadeloupe, *V. pompona* flowers twice a year, during July and again, during November and December. In some years the vanillon flowers almost constantly, being extremely vigorous.

Since the flowers last only a day, time is a most important factor in working a vanilla plantation. One to three flowers on the racemes open each day and remain open from early in the morning to late in the afternoon. The next morning the flowers are withered. A bright day following rain is considered the best time for pollinating the flowers, and a wet day or a period of extreme drought is not propitious for pollination. Nevertheless, there is no choice. The flowers must be pollinated the day they open. To insure the maximum yield of beans, the plantation should be gone over every day during the flowering season. In Mexico, the thousands of flowers which open must be pollinated within a period of about twenty days. Only those flowers attached to the lower side of the rachis should be pollinated since they will later hang perpendicularly toward the ground to form perfectly straight beans. Those flowers attached to the upper side of the rachis should not be pollinated since they will produce crooked beans of inferior quality and less value, which are also difficult to bundle and do not present an attractive appearance.

Hand-pollinating is a delicate procedure, although it is not a difficult operation and is rather easily learned by the most inexperienced worker. It is often the work of women and children who are quick with their hands, and is accomplished merely by placing the pollen masses in contact with the stigma. The only implement needed is a splinter of bamboo, a stem of stiff grass or a slender piece of wood the size and shape of a toothpick sharpened at both ends.

An average worker may pollinate from 1,000 to 2,000 or rarely as many as 3,000 flowers a day (14). Records as to the actual number of flowers pollinated on the various plantations are not available, but about two million flowers are known to have been pollinated in one vanillery during one season (16). If pollination, with consequent fertilization, has been successful the flowers will remain on the rachis; if not, the blossom drops off in two or three days. Consequently, the worker can observe within a few days the number of pods set and can thus discontinue pollinating when the desired number of pods have been obtained for a vine.

The number of fruits which are left to mature on the individual plants varies in different regions. According to Ridley (14), "A good strong vanilla plant in full vigour should produce as many as 200 bunches or racemes of flowers at a time. Each raceme carries from 15 to 20 flowers, or even more. . . . Thus under good conditions a plant can give 4,000 flowers." He recommended that, in some cases, ten fruits be allowed to ripen on each raceme, but in the case of weaker plants only two or three

should be allowed to ripen. If ten fruits were permitted to ripen on each of 200 racemes the plant would produce 2,000 fruits! This seems incredible in view of the fact that a recent author advises that an average cultivated plant will produce upwards of 25 perfect beans, whereas the wild vines produce only an average of three beans (12). In the Seychelles, about thirty beans are usually left to mature on each vine (8). According to the best recent authority, about sixty beans is the maximum number which should be expected from a cultivated vine. Ridley also stated that *V. planifolia* should be made to produce fewer fruits than *V. pompona.* If a plant has been forced to produce an excessive number of beans in one season the beans produced the following season will be inferior and the vines left in a debilitated condition.

After fertilization takes place the ovary elongates rapidly, growing as much as an inch in a week, until the full length of the bean is attained in from four to eight weeks. Depending upon the region where the plants are grown, it takes from three to ten months for the beans to become fully mature. According to Ridley (14), the fruit matures in about four months in the Straits Settlements and Cochin-China, six months in Reúnion, and nine months in Trinidad. Vanilla is usually picked from early November to late in February in Mexico. However, because of the ever-present demand for the beans and also in order to circumvent the stealing of their crops (a general practice), some growers harvest their premature beans as early as October. This premature harvest is said to cause the loss of about one pound in every 1,000 beans (6), and the early harvest of 1940–41 is said to have caused the loss of at least 20% of cured vanilla (11). This economic evil persists and is growing in spite of the Mexican Government's efforts to curb it.

When mature and ready for harvesting, the beans are firm, thick, yellowish green in color and quite scentless. An indication of ripening is a slight yellowing of the whole bean which is more pronounced at the distal end. They must be gathered when fully mature, but before they are too ripe. If gathered too soon they are deficient in aroma and are more subject to attack by a fungus. Long beans are more desirable than short ones since they produce a superior extract, and an eight-inch bean weighs more than two six-inch beans or three five-inch beans (13).

"If left on the plant, the pod begins to turn yellow at the lower end and gives off an odour of bitter almonds. The pod begins to split into two unequal valves, and a small quantity of dark balsamic oil, of a brown or red colour, is produced. Gradually the pod darkens in colour from brown to black. The epidermis softens and the real vanilla odour develops. The oil, which is called 'balsam of vanilla,' then increases in quantity. This balsam is carefully collected by the planters in Peru and other parts of South

America, but not sent to Europe. The pods, ripening slowly upwards from the tip, take about a month to fully ripen. Eventually, if left, the pods become dry and black and brittle, and are then scentless." This excellent account of the ripening of the fruits of vanilla in nature is taken from Ridley (14).

Doubtless the most widespread and serious disease of vanilla is the anthracnose, *Calospora vanillae* Massee. The vegetative apex of the vine, the leaves, and aerial roots are attacked. The fungus is thought to secret a toxin in the soil which affects various parts of the plant when they come in contact with the soil. When plants which have been attacked are transplanted to uninfested soil they soon recover their vigor. This being the case, the vanillery should be established in soil that has never been used for vanilla culture. This disease has affected production of vanilla in the Mascarene, Comoro and Seychelles Islands, the West Indies, Tahiti and Colombia. Ridley (14) states that the disease was first noticed in the Seychelles in 1887 when it was observed that hundreds of the finest and plumpest beans were wilted. They were observed to turn back at the end or in the middle, and fall off in one or two days. It was found that if all dead or dying leaves of infected vanilla vines were destroyed by burning, the disease could be checked or even eradicated. Also, the presence of an excess of moisture in the leaves, prolonged rainy weather, insufficiently drained land, and too much shade were all found to favor the development of the fungus. Overcrowding and excessive moisture were thus conditions to be avoided.

Various other species of fungi have been observed to attack different parts of the vanilla plant. In Tahiti, *Colletotrichum vanillae* Scalia has been found attacking the leaves (14), and in Madagascar *Fusarium batatis* Wollenw. var. *vanillae* Tucker causes root-rot, *Phytophthora parasitica* Dast. causes fruit-rot, and *Glomerella vanillae* (Zimm.) Petch attacks the roots. Other fungi found to be parasitic on the leaves of vanilla in various parts of the world are: *Vermicularia vanilla* Delacr., in Mauritius; *Gloeosporium vanillae* Cooke, in Colombia, Mauritius, and Ceylon; *Uredo scabies* Cooke, in Colombia; *Guignardia traversi* (Cav.) Lind. (10) and *Bacterium briosianum* Pavar., in botanical gardens in Italy; *Macrophoma vanillae* Averna and *Pestalozzia vanillae* Averna, in Brazil; *Physalospora vanillae* Zimm., in Java; and *Atichea vanillae* (Pat.) V. Hoeh., in Tahiti.

In his chapter on vanilla Ridley (14) reviewed quite thoroughly the diseases and pests. A summary of the pests discussed follows. *Trioza litseae* (*Hemiptera, Psyllidae*), the bug most destructive to vanilla, is recorded from Réunion. It attacks the buds and flowers, puncturing them and producing spots of decay. The emerald bug, *Nezara smaragula* Fabr. (=*N. viridula* S.) which is less destructive than *Trioza*, lays its eggs on the

leaves and stalks of vanilla, and the insects when hatched suck the sap of the flower-buds and stalks. The most destructive weevil, *Perissoderes ruficollis* Waterh., is found in Madagascar. A small lamellicorn beetle, *Hoplia retusa* Klug, and an ashy-grey weevil, *Cratopus punctum* Fabr., bite holes in the flowers and often destroy the column. Two moth caterpillars have caused some damage. *Conchylia vanillana* (=*Phalonia*) attacks the young fruits and either causes them to dry up or produces irregular marks on the beans, which spoil them or lower their value as a product. *Plusia aurifera* Hb. (=*Autographa orichalcea* Fabr.) eats the buds of the plant. It is common in Réunion, Madagascar, continental Africa, Saint Helena, Teneriffe and southern Europe. The caterpillar of *Simplica inarcualis* Guen. is also supposed to attack vanilla on occasions.

In planning and establishing a plantation, additional factors to those discussed above have to be considered. Foremost of these is the selection of the location. The plantation, of necessity, should be located in a region where a sufficient supply of cheap and intelligent labor is available, because vanilla cultivation is an expensive operation at best. For this reason, as well as for climatic considerations, the largest vanilla plantations have been developed in the eastern hemisphere in comparatively isolated places with a large native population. The lack of abundant cheap labor in tropical America has been a major deterrent to the establishment of vanilla, as well as certain other tropical crops, on a large plantation basis in this hemisphere. Most of the commercial vanilla produced in tropical America is grown by small, independent "farmers" whose family, with possibly a few helpers, does all the work. Much vanilla is still gathered in the wild state.

Puerto Rico has available land in regions suitable for growing vanilla, especially in the coffee area, and a continued effort has been made to establish this industry on the island so as to supply the markets of the United States. Encouragement should also be given this crop in other suitable areas of tropical America. The Agricultural Experiment Station of Puerto Rico has been doing research on vanilla for a number of years, and the accumulated knowledge concerning this crop should be useful for all tropical America. McClelland (13), in 1919, strongly advocated the growing of this crop in Puerto Rico and more recently, in 1935 (4), the industry was again urged for this island. The disadvantages of growing the crop in Puerto Rico were found to be (4)—(a) lack of experience in curing and packing methods, (b) difficulty in financing the undertaking, (c) lack of an established reputation, (d) damage caused by root diseases (shared by all vanilla-producing countries), and (e) comparatively high cost of labor. There is little doubt that Puerto Rico can supply a large part of the vanilla beans needed in the United States if a well planned program can be developed and followed through in vanilla cultivation on the island.

HARVESTING, CURING AND PROCESSING THE BEANS

During the harvesting season the beans, which do not mature simultaneously, should be gathered every day. They should not be allowed to reach full maturity, and should be picked before reaching the stage of dehiscing on the vine since split beans are considered inferior to those which are not split. The beans are ready for cutting or picking when they become yellowish and develop a hard, black tip. They may be easily removed unbroken from the vines by a sidewise pressure of the thumb placed at the base. Twisting should be avoided so as not to break the bean. If any portion of the vine comes away with the fruit it should be cut away without injuring the base of the bean. On many plantations, instead of picking, the beans are cut from the vines with a sharp knife. After each day's gathering, for convenience in future sorting, the beans should be roughly divided into four classes: long, medium, short and split.

There are various artificial methods used in curing, or completing the ripening of vanilla fruits, foremost of which are the use of sun heat (Mexican process), of hot water (Bourbon process), or of stove heat. Although they may differ somewhat in technique, all the methods have the same purpose of obtaining as rapidly as possible uniformly cured, unsplit beans. Curing is a process of alternately sweating and drying the beans until they have lost most of their moisture, as much as 80% being lost in curing Mexican beans The curing process should begin within a week after the beans are harvested. In Mexico, the curing process is carried out during the dry season, which extends from November to May. The beans may be cured by the grower, but for the most part the green beans are brought by mule-train or men to trading centers and are sold direct to curer-exporters, who are not only specialists in this work but have adequate facilities for curing the beans. The curer's lot is full of problems. He buys the beans by weight, taking into consideration the odor, oil content, and time of harvest and, in turn, sells his finished product by weight.

In Mexico, where the best vanilla is grown, the beans are gathered and stored in sheds for a few days until they begin to shrivel. If the weather is fair they are then spread on woolen blankets in the sun for a few hours until too hot to hold in the bare hands, after which the blanket is folded over them for the rest of the day. At the end of the day the bundles of beans are removed to blanket-lined, air-tight containers where they sweat all night. This process, which may take as much as two weeks or longer, is repeated until the beans turn a dark chocolate brown color. In case of cloudy weather, the larger beans are wrapped in blankets, sprinkled with water, and are heated in an oven to 140°F. When the temperature has dropped to 113°F. the smaller ones are inserted (14). After twenty-four hours the small beans are removed and twelve hours later the large ones

are taken out. During this process the beans have sweated and acquired the desired rich brown color.

After the sweating process, the beans are spread out on grass mats in the sun every day for about two months or longer, after which they are spread in a shelter until they are sufficiently dry and ready for market. Care should be taken not to over-expose the beans to the sun since this will cause them to be dry, less aromatic and of a reddish instead of deep brown color. In Mexico, it takes from five to six months to bring the beans to a state of perfection. In Réunion, not only the above process is used, but often the sweating stage is preceded by one (15 to 20 seconds) or several shorter periods (3 to 4 seconds) of immersion in water heated to within a few degrees of the boiling point. This, the Bourbon process, takes about three months to bring the beans to a state of perfection, and they are never so dry as the Mexican beans. Modifications of the above methods are practiced throughout the tropics wherever vanilla is grown. In recent years research has been undertaken by the Mexican Government to improve and hasten the slow and expensive methods of curing the beans, but as yet no results have been published.

The so-called Guiana process consists of placing the beans in ashes until they shrivel, after which they are rubbed with olive oil, tied to prevent splitting, and hung in the open air until dry; the Peruvian process includes dipping the beans in boiling water, after which they are dried in the open air for three weeks and then lightly rubbed with castor oil (14). A nunber of other such primitive processes are used in various regions.

When properly cured and dried vanilla beans should be almost black and supple enough to be twisted round the finger without rupturing. Before being packed they are usually smoothed and straightened by being drawn repeatedly through the fingers. This massaging helps to bring out some of the oil which exudes during fermentation, and gives the beans their characteristic lustre. Some beans are said to be oiled with mahogany-oil to render them supple and to preserve them from insects (7). Usually the beans are covered with white needle-shaped crystals of vanillin, the presence of which is considered by some to be a criterion of quality.

"Apart from the attractive crystals on the outside, the main pocket-lens features of the vanilla pod lie inside. The pericarp or fruit-wall has about twenty conducting strands, and three dark lines marking the limits of the valves which normally open as only two, one single and flattish, the other double and curved in cross-section. The central cavity is packed with numerous small black seeds embedded in a gummy oleo-resinous matrix which is secreted by three bands of fine hairs occupying the corners of the more or less triangular cavity. The seeds are developed in twelve rows, on three pairs of placentae, each placental ridge having two lateral rows of seeds. These structural details are rather difficult to distinguish in a dry pod, but a cross-section shows some indications of strands and

placentae in the pericarp, and also the mass of seeds and secretions in the center" (16).

Vanilla beans are subject to attacks from mildew, especially if they are improperly cured and have not been sufficiently dried. Once the beans become permeated with the odor of mold, it is practically impossible to eliminate it and the value of the bean is much reduced. The moldy portion is cut away and the remainder of the beans, known as "cuts," is sold for perfuming soaps, etc. In Mexico, these "cuts" normally average from 10 to 20 per cent of the crop, but when the demand for vanilla is heavy, especially early in the season, and the prices are good, the number of "cuts" increase (11). The time of curing is less and the packing for shipping is easier than for whole first quality beans. Not all the "cuts," however, are the result of mildew. Dealers in vanilla often try to remove the mildew by washing the beans in alcohol and rubbing them with glycerin, and try to prevent its reappearance by the use of formaldehyde, but the moldy odor will persist. Beans with more than 36% moisture content are considered to be subject to molding (14).

Vanilla beans are always marketable so long as they are well-cured, of sound keeping qualities, and possess a sweet flavor. They will keep indefinitely if properly cured and stored. The value of vanilla depends almost entirely upon the curing and packing of the beans. During the curing process the beans are continually under observation so that any which may be moldy or in any way defective can be removed. The same intensive care is given to sorting and packing the fruits.

The beans are sorted into several classes, primarily as to quality and length, before being packed. The best beans are without defects, being oily, smooth, strongly aromatic and essentially black. The second class beans are somewhat defective in that they are over-dried, less aromatic, have a rough exterior and are somewhat reddish in color. The split beans, which have lost some of their perfume, comprise the third class. The first class beans often weigh as much as twelve or more ounces each.

The vanilla beans of commerce have been divided for convenience into four principal geographic types—Mexican, Bourbon, South American (including vanillon, West Indian vanilla, and pompona) and Tahiti. Mexican beans come from Mexico only. Bourbon beans were originally from the Island of Réunion (Bourbon) only, but they now include all beans grown in the Mascarene, Comoro and Seychelles Islands. The Bourbon crop is handled almost entirely through France. South American beans are grown mainly in the French West Indies, and Tahiti beans are an inferior vanilla grown in the French group of the Society Islands. The crops are large in Tahiti, but the beans are usually rank in flavor. Java beans, which may be considered a fifth type, are grown in the Netherlands Indies, the bulk of the crop going to Holland.

"In Mexico five classes of vanilla are known. The best is *primera*, the

pods of which are 24 cm. long and proportionally thick; the second are called *chica prima*, the pods being shorter and two counting as one; the third is *sacate;* the fourth, *vesacate*, are still smaller, and are gathered before they are ripe; the fifth quality is *basura*, with small, spotted, and much broken pods." (14) The *sacate* is said to be a large bean which grows abundantly along the roadsides in the warm regions of Mexico, where formerly its fruit was considered to be without commercial value (6). The Mexican beans are usually larger and darker in color than those produced elsewhere.

After sorting, the beans are either sold in bulk or are tied in bundles of fifty to ninety each and packed in tin boxes containing as much as 85 pounds (14). After being soldered up three tins each are placed in wooden cases, preferably cedar, and are ready for shipment. The fruits of *V. pompona*, vanillon, are not mixed with those of *V. planifolia* and are packed separately or sold in bulk.

There are a number of methods for preparing vanilla extract, but percolation processes are the most widely used. The beans are first finely chopped and are then placed in a percolator, after which a thirty-five to sixty-five per cent solution of ethyl alcohol is poured over them. As this diluted alcohol drips through the beans it becomes saturated with the extractive and sinks to the bottom of the percolator where it is repeatedly drawn off and poured over the beans again until the maximum of vanillin removed. It is then allowed to age before being placed on the market. Another method which is essentially the same, but is more modern and mechanical, involves a circulatory percolation whereby the solvent is pumped from the bottom of the tank and allowed to repercolate. This steady circulation of the solvent through the chopped beans is continued until the concentration of vanillin is the same at the top and bottom of the tank, when the liquid is drawn off and allowed to age.

According to the United States food and drug laws, vanilla extract is the flavoring extract prepared from vanilla beans, with or without sugar or glycerin, and contains in 100 cubic centimeters the soluble matter from not less than ten grams of the vanilla bean. Based on this standard, it takes 13.34 ounces of beans to make one gallon of finished extract.

SUBSTITUTES AND MISCELLANEOUS INFORMATION

A number of related and unrelated plants have flowers, fruits or vegetative parts which emit the odor of vanilla. While some are of no apparent use, others have been used as a substitute for, or adulterant of, commercial vanilla. The long, cylindrical pods of "chica vanilla" (little vanilla), *Selenipedium chica* Reichb. f., are said to have been highly esteemed at one time by the inhabitants of the Isthmus of Panama. These pods were used for all purposes for which real vanilla is commonly used. The Faham

or Bourbon tea leaves, of the Mascarene Islands, from the orchid *Angraecum fragrans* Thou., and the dried leaves of *Orchis fusca* Jacq., of Eurasia, are said to possess the odor of vanilla (7). The familiar fragrant ladies' tresses, *Spiranthes cernua* (L.) L. C. Rich. var. *odorata* (Nutt.) Correll, of the eastern and southern United States, has flowers which are strongly fragrant of vanilla.

The attractive herb, *Trilisa odoratissima* (Walt.) Cass., or "vanilla-plant," found on the coastal plain of the southeastern United States, was at one time used as a vanilla substitute. The leaves contain a large amount of coumarin and were used primarily as a flavoring agent for tobacco. The plant was extensively gathered and, about 1875, one dealer at the trading center of Palatka, Florida, had an order to fill of 150,000 pounds (2). Although used to some extent in this country, a much larger quantity was shipped to Germany and France. It is still used for this purpose. The little orchid "herb vanilla," *Nigritella angustifolia* Rich., which grows in the mountains of Switzerland, is said to derive its common name from the fact that on hot days it emits a powerful odor similar to that of vanilla (7). The common sweet clovers, *Melilotus spp.*, contain coumarin and have the slight odor of vanilla.

The most widely used vegetable substitute and most notorious adulterant of vanilla is the tonka or "snuff bean," *Dipteryx odorata* (Aubl.) Willd., a leguminous tree native to northern South America and Trinidad. The latter place has a virtual monopoly of this product. The beans usually sell for approximately fifty cents a pound, and are chiefly sold in the United States, with a smaller market in Europe. They contain a high percentage of coumarin and are used mainly in the manufacture of tobacco and perfume, and to a lesser extent in confections and the flavoring of liqueurs. Another tonka bean, *D. oppositifolia* Willd., is also said to be used as a vanilla substitute. The vanilla-like odor of the tonka bean is attributed to the large amount of coumarin present. This substance, if taken in too large a quantity, is said to produce poisonous effects, thirty to sixty grains being sufficient to cause nausea, depression and drowsiness (7).

Some little known and less common wild vanillas are thought to be used as adulterants of the true vanilla of commerce. The vanillon, *V. pompona*, is the species commonly used for this purpose, but there are doubtless others. According to Small (16), manipulated vanilla beans which have been exhausted and redried or roasted are sometimes sprinkled with crystals of benzoic acid, which simulate crystals of vanillin, and are placed on the market. These benzoic acid crystals, however, do not yield the carmine-red color given by vanillin with phloroglucin and hydrochloric acid. Synthetic vanillin crystals are sometimes sprinkled over low grade or "treated" beans to improve their appearance. Heliotropine, cinnamic acid

derivatives and various perfumes are also said to be used as adulterants of vanilla. Perhaps the most common method of adulterating vanilla extract, and the most difficult to detect, is the use of fewer beans than the standard requirements. Although not used as a flavoring, the expressed juice of the fruits of a species identified as *V. claviculata*, native to the West Indies, is said to be applied to recent wounds and is called "liana a blessure" by the French in Santo Domingo (1).

An unfortunate phase in the development of the vanilla industry is that relating to so-called "vanilla poisonings," which gained prominence during the last century, especially those following the eating of ice cream and vanilla ices. Foreign substances which were introduced through ignorance, accidentally or as adulterants in the vanilla beans and extract were found to be the source of most of the poisonings. Some instances of poisoning were thought to have been caused by the presence of *tyrotoxicon*, a poison found in milk which has undergone certain putrefactive changes, or perhaps to the presence of microscopic organisms in the vanilla, since the plantations are liable to the attack of *Bacterium putredinis* Weinberg *et al.* (7), etc. The presence of cardol, or the oil of the cashew nut, was also thought to cause some poisonings since this was occasionally used to improve the appearance of the vanilla bean. "These cases are distinct from those in which the poisoning has been caused by the admixture of dangerous metallic substances." (7). In no instance was it found that vanilla, as such, caused poisoning.

Persons employed in handling vanilla occasionally suffer from an ailment known as "vanillism." According to Ridley (14), "It takes the form of headache, gastric trouble, and urtication, or a kind of rash. The latter is perhaps caused by the crystals of oxalate of lime which are so abundant all through the plant. The juice of the leaves and stalks of some species at least is very irritating to the skin, and the leaf of the cultivated vanilla is used as a blistering agent in Réunion. That of the wild species of the Malay Peninsula, which produces a considerable amount of irritation on the softer part of the skin, is used by the Malays as a stimulant to the growth of the hair." Irritation of the skin is also thought to be caused by an *Acarus*, a mite, which sometimes occupies the end of the bean (7).

The chief competitor of natural vanilla and the product which is commonly used to fortify the pure extract is synthetic vanillin, or artificial vanilla. Methyl vanillin and ethyl vanillin are also sometimes utilized. All of these are many times stronger than the natural extract but do not match it in quality. Ethyl vanillin is said to be about three times as strong as methyl vanillin, and has a superior, stronger and more delicate odor which comes nearest to the peculiar aroma of Bourbon vanilla beans (9). Another material, vanillic acid ester of vanilla alcohol, is said to be at least twice as strong as vanillin and has been strongly advocated as a

flavor (9), especially during the present emergency when shortages of containers and transportation facilities necessitate reduction and concentration of all products insofar as possible. A small amount of vanillic acid ester is equal in flavoring potency to a large bulk of natural vanilla extract and would, consequently, be more practical for overseas shipments.

These products, which cost only a fraction of that of pure vanilla extract, have not seriously affected vanilla culture, but have been an important factor in reducing the rather exhoribtant prices once paid for vanilla beans. Most vanilla beans grown today have a market before they are harvested. In fact, the total crop grown throughout the world is insufficient to satisfy the needs, and the steady demand for the natural flavoring would seem to warrant the development of additional plantations, especially in Puerto Rico and other regions near to the United States.

German chemists were the first to place synthetic vanillin on the market. It was " . . . first produced in 1874 by Tiemann, through a process of oxidation with Shromic Acid of the Glucoside Coniferin, which occurs in the cambium of various coniferous woods." (9). Later, in 1891, the French chemist, De Taire, extracted vanillin from eugenol, which occurs in oil of cloves. The latter is still the primary source of commercial "vanillin." Of late, however, vanillin has been produced in large quantities from wood pulp. This, the original Tiemann process, is that which is used in Germany today. Artificial vanillin has also been obtained by electrolysis from sugar, from asafoetida, *Ferula assa-foetida*, L., Siam benzoin, *Styrax tonkinensis* (Pierre) Craib, and from a coal tar product. "Other materials were used as a base to produce this important aromatic chemical, namely Guaiacel Orthe Anisidine." (9). Vanillin can also be produced from heliotropine, which, in turn, is made from safrol. "The latter can be made from Oil of Sassafras, which is a distillate of Sassafras Bark." (9). Since the sassafras, *Sassafras albidum* (Nutt.) Nees, grows rather extensively in the Carolinas, Kentucky and elsewhere in the eastern and central United States, this source of artificial vanillin should almost be sufficient if all other sources were made unavailable. "Vanillin does not appear to have any physiological action on human beings when taken in small doses, as much as 10 to 15 grains having been administered without noxious results. On small animals, however, such as frogs, it appears to act as a convulsive. It has been suggested as a stimulant of an excito-motor character in atonic dyspepsia." (7).

A number of imitation vanilla extracts, which may or may not contain a certain percentage of pure vanilla extract, have been placed on the market. A small amount of pure vanilla, as little as ten per cent, usually greatly improves the flavor of these imitation extracts. Extract of tonka beans and coumarin are the primary sources of these extracts, although

a number of synthetic chemicals are used, as ethyl vanillin, piperonal, various perfumes and cinnamic acid derivatives. Other materials which have been used are raisin and prune juices, maple sugar, St. John's bread, *Ceratonia siliqua* L., and fenugreek, *Trigonella foenum-graecum* L.

Although science has devised substitutes for this popular flavoring material, vanilla, like so many other natural products which have been synthesized, should survive these encroachments. The delicate, ephemeral essence of the natural product, which leaves no unpleasant after-taste, has not been completely captured by the test tube. There will doubtless be a future market for all first quality beans which may be grown.

LITERATURE CITED

1. ANONYMOUS. 1875. *The Vanilla.* Pharm. Journ. and Trans., ser. 3, **5**: 24–25.
2. ———. 1875. *The Wild Vanilla Plant.* Pharm. Journ. and Trans., ser. 3, **5**: 489–490.
3. ———. 1915. *Vanilla.* Mo. Bot. Gard. Bull. **3**: 109–112.
4. BUREAU OF AGRIC. AND INDUSTR. RESEARCH. 1935. *Outlook for Vanilla Cultivation in Puerto Rico.* 62 pp. San Juan, P.R.
5. CHALOT, C. AND U. BERNARD. 1920. *Culture et Préparation de la Vanille.* 215 pp. Paris.
6. CUNNINGHAM, C. H. 1920. *Vanilla Production in Mexico.* Commerce Reports, November.
7. FERGUSON, A. M. AND J. FERGUSON. 1889(?). *All About Spices.* pp. 149–184. [A reprint of various articles and items relating to vanilla.] Colombo, Ceylon.
8. GALBRAITH, S. J. 1898. *Vanilla Culture as Practiced in the Seychelles Islands.* U. S. Dept. Agric. Bull. **21**: 24 pp.
9. KATZ, A. E. 1943. *Natural and Synthetic Flavoring Materials*, etc. The Spice Mill **66**: 12, 34–35.
10. LECOMTE, H. AND M. C. CHALOT. 1901. *Le Vanillier.* 288 pp. Paris.
11. MALLORY, L. D., WALTER, D. F. AND KAROLYNE WALTER. 1942. *Mexico's Vanilla Production.* Foreign Commerce Weekly **7**: 8–10, 23.
12. MATSCHAT, C. H. 1934. *Vanilla—The Orchid of Commerce.* Orch. Rev. **42**: 46–50.
13. MCCLELLAND, T. B. 1919. Vanilla: *A Promising New Crop for Porto Rico.* Porto Rico Agric. Expt. Sta. Bull. **26**: 32 pp.
14. RIDLEY, H. N. 1912. *Spices.* Pp. 23–93. London.
15. ROLFE, R. A. 1896. *A Revision of the Genus Vanilla.* Journ. Linn. Soc. Bot. **32**: 439–478.
16. SMALL, J. 1942. *Vanilla: A Pocket-lens Study.* Food-processing, Packeting, Marketing. Pp. 137–141. London.

Diagnoses of Hawaiian Species of Pelea (Rutaceae)
Hawaiian Plant Studies, 13[1]

HAROLD ST. JOHN
(University of Hawaii, Honolulu)

For a number of years the writer has investigated in the field and studied in herbaria the genus *Pelea*. He intends to publish a monograph of it. In response to demands to make his discoveries available in advance of the monograph, the following preliminary diagnoses of the new species and varieties and the new combinations are issued. Many of them are published jointly with a former student, Dr. Edward P. Hume of Cornell University. The abbreviations for herbaria are the standard ones from the International List by J. Lanjouw (Chron. Bot. **3**: 345–349, 1937).

MICROCARPAE

Pelea clusiaefolia Gray var. **Cookeana** (Rock) St. John & Hume, comb. nov.

P. Cookeana Rock, Ind. Trees Haw. Ids. 216, 1913.
P. clusiaefolia Grayγ var. Hbd., Fl. Haw. Ids. 63, 1888.

P. clusiaefolia Gray var. **cuneata** St. John & Hume, var. nov.

Foliis obovatis cuneatis glabris vel ad costam pilosis, capsulis 12–14 mm. diametro glabris $\frac{1}{2}$-lobatis.

Typus, Hawaii, Kipuka Puaulu, Kilauea, *J. F. Rock* 13,037, (Ho.).

P. clusiaefolia Gray var. **dumosa** (Rock) St. John & Hume, comb. nov.

P. sapotaefolia Mann var. *dumosa* Rock, Ind. Trees Haw. Ids. 218, 1913.

P. clusiaefolia Gray var. **ecuneata** St. John, var. nov.

Foliis glabris plerumque ad basim rotundatis.

Typus, Kauai, Hanapepe, Dec. 1909, *U. Faurie* 187, (BM.).

P. clusiaefolia Gray var. **Fauriei** (Lévl.) St. John & Hume, comb. nov.

P. Fauriei Lévl., Fedde Report. Sp. Nov. **10**: 153, 1911.

P. clusiaefolia Gray var. **sapotaefolia** (Mann) St. John, comb. nov.

P. sapotaefolia Mann, Proc. Boston Soc. Nat. Hist. **10**: 312–313, 1866.
P. microcarpa Heller, Minn. Bot. Stud. **1**: 839–840, pl. 49, 1897.

P. clusiaefolia Gray var. **puberula** St. John, var. nov.

A var. *sapotaefolia* paginis inferioribus puberulis differt.

Typus, Oahu, Pupukea, Jan. 29, 1927, *L. H. MacDaniels* 545, (Ho.).

[1] This is the thirteenth of a series of papers designed to present descriptions, revisions, and records of Hawaiian plants. The preceding papers have been published as Occ. Papers Bishop Mus. **10**(4), 1933; **10**(12), 1934; **11**(14), 1935; **12**(8), 1936; **14**(8), 1938; **15**(1), 1939; **15**(2), 1939; **15**(22), 1940; **15**(28), 1940; and nos. 11 and 12 are in press.

P. descendens St. John, sp. nov.

Frutex (?), novelles sparse puberulis deinde glabratis, ramulis glabris, foliis oppositis, petiolis maturis glabris, laminis 3–9 cm. longis spatulato-ellipticis glabris ad apicem emarginatis, pedunculis 1-floriferis 17–19 mm. longis glabris, capsulis 13–17 mm. diametro $\frac{3}{4}$-lobatis glabris, lobis valde reflexis, endocarpio glabro.

Typus, Oahu, s. ridge, Kipapa Gulch, moist wooded ridge, el. 1,800 ft., Oct. 16, 1932, *E. Y. Hosaka* 820, (Ho.).

P. Hosakae St. John, sp. nov.

Arbor 8 m. alta, novellis cinereis puberulis, ramulis puberulis, foliis oppositis, petiolis puberulis vel glabratis, laminis 9–23 cm. longis ovalibus vel ellipticis subcoriaceis glabris sed infra costa puberulenta, cymis 5–11-floriferis puberulis, pedunculis 5–10 mm. longis pedicellis 7–10 mm. longis, capsulis 9–18 mm. diametro dense cinereo-puberulis $\frac{2}{3}$-lobatis, lobis rotatis, endocarpio velutino.

Typus, Oahu, Kipapa Gulch, Waipio, el. 1,700 ft., May 6, 1933, *E. Y. Hosaka* 1,006, (Ho.).

P. olowaluensis St. John, sp. nov.

Arbor 3 m. alta, ramulis minute puberulis glabratis, foliis oppositis, petiolis glabris, laminis 2.8–8 cm. longis ovalibus subcoriaceis glabris, cymis trifloris glabris, pedunculo 9 mm. longo, capsulis glabris 16–20 mm. diametro 6 mm. altis $\frac{1}{2}$-lobatis, endocarpiis glabris.

Typus, Maui, Olowalu Valley, central ridge, May 12, 1920, *C. N. Forbes* 2,326.M, (Ho.).

P. Pickeringii St. John, sp. nov.

Ramis glabris, foliis oppositis, petiolis adpressi-hirsutulis, laminis 5–7.7 cm. longis obovatis cuneatis glabratis subcoriaceis reticulatis glanduloso-punctatis, capsulis glabris coriaceis $\frac{3}{4}$-lobatis apicibus obtusis.

Typus, Sandwich Island, 1838–42, *Wilkes Expedition*, (Ca.-Gr.).

P. pluvialis St. John, sp. nov.

Arbor (?), novellis puberulis, ramulis glabratis, foliis oppositis, laminis 7–18 cm. longis ellipticis subcoriaceis glabris, cymis glabris 4–5-floriferis, pedunculis 6–12 mm. longis, capsulis glabris 16 mm. diametro 11 mm. alto $\frac{2}{3}$-lobatis, endocarpiis glabris.

Typus, Kauai, Waialeale, Sept. 20, 1910, *J. F. Rock* 5,040, (Ho.).

P. puberula St. John, sp. nov.

Frutex (?), novellis pilosis, ramulis sparse pilosis, foliis oppositis, petiolis pilosis deinde glabratis, laminis 4.5–6 cm. longis ovalibus coriaceis supra glabris infra villosis ad apicem emarginatis, cymis 5-floriferis pilosis, pedunculis 8–15 mm. longis, pedicellis 8–9 mm. longis, capsulis 12–13

mm. diametro puberulis $\frac{1}{2}$-lobatis, lobis rotatis inaequalibus, endocarpio sparse pilosulo.

Typus, Kauai, Alakai Swamp, near Puu o Kila, alt. 4,000 ft., July 21, 1937, *E. C. Zimmerman*, without number, (Ho.).

P. punctata St. John & Hume, sp. nov.

Ramis glabratis, foliis oppositis, petiolis glabratis, laminis obovatis glabratis, capsulis glabris 18 mm. diametro $\frac{3}{4}$-lobatis.

Typus, Kauai, Kahili Swamp, Wahiawa, Dec. 29, 1930, *H. St. John et al.* 10,852, (Ho.).

P. ukuleleensis St. John, sp. nov.

Ramulis hirsutulis, petiolis dense hirsutulis, laminis 4.5–8.5 cm. longis ellipticis vel ovalibus coriaceis infra glabratis, costa hirsuta, cymis hirsutulis 5–9-floriferis, capsulis glabris $\frac{2}{3}$-lobatis, endocarpiis glabris.

Typus, Maui, Ukulele, July 1919, *C. N. Forbes* 749.M, (Ho.).

P. wahiawaensis St. John & Hume, sp. nov.

Ramis glabris, foliis oppositis, laminis ellipticis glabris, capsulis 16–18 mm. diametro $\frac{1}{2}$-lobatis.

Typus, Kauai, Wahiawa Swamp, *C. N. Forbes* 282.K, (Ho.).

P. waipioensis St. John, sp. nov.

Arbor 7 m. alta, novellis adpressi-hirsutulis, ramulis hirsutulis demum glabratis, foliis oppositis, petiolis hirsutulis demum glabratis, laminis 4.5–9.5 cm. longis obovatis ad basim subcuneatis ad apicem emarginatis vel obtusis coriaceis supra glabris infra costa sparse adpressi-hirsutula glabrata, cymis 7–13-floriferis puberulis, pedunculis 4–6 mm. longis, pedicellis 3–6 mm. longis, capsulis 13–15 mm. diametro glabris $\frac{2}{3}$-lobatis reticulatis, endocarpio sparse puberulo.

Typus, Oahu, Kipapa Gulch, Waipio, el. 2,200 ft., Feb. 10, 1935, *E. Y. Hosaka* 1,270, (Ho.).

P. waialeale Wawra var. **latior** St. John & Hume, var. nov.

Foliis 6.5–9.8 cm. longis, 2.5–4.1 cm. latis.

Typus, Kauai, n. w. end of Alakai Swamp, Dec. 27, 1930, *H. St. John et al.* 10,776, (Ho.).

MEGACARPAE

P. apoda St. John, sp. nov.

Arbor vel frutex, novellis hirsutis, internodiis ramulorum glabratis, ramis glabratis, foliis oppositis sessilibus, laminis 1.8–6.3 cm. longis ovalibus coriaceis ad apicem emarginatis ad basim cordatis supra glabris infra hirsutis ad basim et in nervo medio deinde subglabratis, cymis 3–5-flori-

feris in nodis hirsutis, pedunculis 2–8 mm. longis, pedicellis 2 cm. longis, capsulis 22–24 mm. diametro glabris $\frac{5}{6}$-lobatis, lobis recurvatis, endocarpio glabro.

Typus, Hawaii, Volcano region, July–Aug., 1918, *J. F. Rock*, without number, (Ho.).

P. Christophersenii St. John, sp. nov.

Arbor (?), novellis adpressi-puberulis, ramis petiolisque glabratis, foliis oppositis cito glabratis 4.5–12 cm. longis ovalibus coriaceis infra valde rugoso-nervosis, cymis adpressi-puberulis 9–15-floriferis (?), capsulis $\frac{3}{4}$-lobatis 25–32 mm. diametro puberulis lobis rotatis, endocarpio puberulento.

Typus, Oahu, top of Kaala, May 10–15, 1931, *E. Christophersen & E. P. Hume* 1,804, (Ho.).

P. grandifolia (Hbd.) St. John & Hume, comb. nov.

P. volcanica Gray β var. *grandifolia* Hbd., Fl. Haw. Ids. 67, 1888.

P. grandifolia (Hbd.) St. John & Hume var. **ovalifolia** (Hbd.) St. John, comb. nov.

P. volcanica Gray var. *ovalifolia* Hbd., Fl. Haw. Ids. 67, 1888.

P. honoluluensis St. John, sp. nov.

P. sandwicensis sensu Rock, Ind. Trees Haw. Ids. 224, pl. 85, 1913, non (Gaud.) Gray vel (H. & A.) Gray.

Typus, Oahu, Konahuanui, *J. F. Rock* 10,215, (Ho.).

P. kaalaensis St. John, sp. nov.

Foliis oppositis, laminis ellipticis 7–22 cm. longis coriaceis infra villosis, petiolis adpressi-hirsutulis cinereis, pedicellis 4–7 mm. longis, capsulis 28–32 mm. diametro valde puberulis $\frac{1}{2}$–$\frac{2}{3}$-lobatis, endocarpio pilosulo.

Typus, Oahu, Makaha Valley, Kaala Range, Feb. 12–19, 1909, *C. N. Forbes*, without number, (Ho.).

P. hualalaiensis St. John, sp. nov.

Frutex vel arbor (?), novellis ramulisque dense villosis, ramis villosis deinde glabratis, foliis oppositis, petiolis 5–23 mm. longis villosis, laminis 3–9.5 cm. longis ellipticis vel ovalibus coriaceis supra glabris sed nervo medio ad basim villoso infra ab initio villoso deinde sparse villosis sed nervo medio dense villoso, cymis 5-floriferis pilosis, pedunculis 10–15 mm. longis, pedicellis 10–13 mm. longis, capsulis 25–30 mm. diametro $\frac{3}{4}$-lobatis puberulis, lobis valde reflexis, endocarpio glabro.

Typus, Hawaii, Puu Hualalai, Puuwaawaa, 4,800 ft. alt., woods, Dec. 21, 1931, *H. St. John, J. W. Coulter, E. Y. Hashimoto, J. C. Lindsay, & D. D. Mitchell* 11,362, (Ho.).

P. kauaensis St. John, sp. nov.

Arbusculus, novellis hirsutis, ramulis sparse hirsutis, foliis oppositis, petiolis hirsutis, laminis 5.5–11 cm. longis ovalibus coriaceis infra reticulatis sparse hirsutis subglabratis costa sparse hirsuta, cymis 3–5-floriferis, pedunculis 5–9 mm. longis sparse puberulis, pedicellis 5 mm. longis, capsulis 30–38 mm. diametro puberulis $\frac{3}{4}$-lobatis lobis semireflexis reticulatis, endocarpio pilosulo.

Typus, Oahu, Puu Kaua, 2,000 ft., Nov. 6, 1932, *Amy Suehiro*, without number, (Ho.).

P. lanceolata St. John & Hume, sp. nov.

Ramis glabris, foliis oppositis, petiolis glabris, laminis lanceolatis 4.5–9.5 cm. longis glabris, capsulis 20–24 mm. diametro $\frac{3}{4}$-lobatis.

Typus, Hawaii, Kapapala (Puuaulu), Aug. 7, 1911, *C. N. Forbes* 399. H. partim (Ho.).

P. lucens (Hbd.) St. John, comb. nov.

P. sandwicensis [Gray]=(H. & A.) Gray var. *lucens* Hbd., Fl. Haw. Ids. 67, 1888.

P. Munroi St. John, sp. nov.

Frutex, novellis pilosis, internodiis glabratis, foliis oppositis, petiolis 2–9 mm. longis, laminis 5–12 cm. longis ovalibus vel suborbicularibus coriaceis glabratis vel nervo medio piloso, cymis 5–12-floriferis sparse puberulis, pedicellis 15–40 mm. longis, capsulis immaturis 18 mm. diametro glabris $\frac{2}{3}$-lobatis, endocarpiis pilosis.

Typus, Lanai, Lanaihale, April 16, 1915, *G. C. Munro*, without number, (Ho.).

P. manukaensis St. John, sp. nov.

Frutex 6 m. alta, novellis cinereis puberulis, ramulis adpressi-puberulis, nodis puberulis hirsutulisque, ramis glabratis, foliis oppositis, petiolis 5–15 mm. longis adpressi-puberulis, laminis 3.5–14 cm. longis, ellipticis ovalibusve subtiliter coriaceis utrinque glabris sed nervo medio puberulo, cymis 3-floriferis adpressi-puberulis, pedunculis 4–8 mm. longis, pedicellis 7–12 mm. longis, capsulis 21–26 mm. diametro $\frac{3}{4}$-lobatis, lobis rotatis, endocarpio glabro.

Typus, Hawaii, Manuka Mauka, South Kona, 2,000 ft. alt., Dec. 24, 1931, *H. St. John, E. Y. Hashimoto, E. Y. Hosaka, J. C. Lindsay, & D. D. Mitchell* 11,289, (Ho.).

P. oblanceolata St. John, sp. nov.

Arbor vel frutex, novellis dense hirsutulis, ramulis sparse hirsutulis, ramis glabratis, foliis oppositis, petiolis 2–4 cm. longis canaliculatis glabratis, laminis 9–16 cm. longis oblanceo-ellipticis coriaceis obtusis vel

emarginatis supra glabris infra hirsutulis glabratis nervo medio hirsutulo, cymis 1–3-floriferis infra hirsutulis supra glabratis, pedunculis 5–12 mm. longis, pedicellis 15 mm. longis, capsulis 30–37 mm. diametro glabris ¾-lobatis, lobis rotatis glabris, endocarpio glabro.

Typus, Hawaii, Kulani Forest, Aug. 1918, *J. F. Rock*, without number, (Ho.).

P. orbicularis Hbd. var. **tonsa** St. John & Hume, var. nov.

Foliis glabris, paniculis sparse pilosulis.

Typus, Maui, Iao Valley, *C. N. Forbes* 89.M, (Ho.).

P. paloloensis St. John, sp. nov.

Arbor parvus glabratus, novellis adpressi-puberulis, foliis 3–4-verticillatis petiolatis, laminis 8–13 cm. longis anguste ellipticis vel oblanceolatis subcoriaceis glabris, cymis sparse adpressi-puberulis circa 13-floriferis, pedunculis 16–30 mm. longis, pedicellis 2–11 mm. longis, capsulis 18–22 mm. diametro ⅔-lobatis glabris, basi concavo, endocarpiis glabris.

Typus, Oahu, between Palolo and Waialae Iki, Jan. 30, 1917, *C. N. Forbes* 2,404.O, (Ho.).

P. puauluensis St. John, sp. nov.

Arbor 7 m. alta, novellis dense hirsutulis, ramulis hirsutulis, ramis hirsutulis deinde glabratis, foliis oppositis, petiolis 7–13 mm. longis adpressi-hirsutulis, laminis 3–8 cm. longis late ovalibus coriaceis emarginatis supra glabris infra glabratis nervo medio hirsutulo, cymis 3–7-floriferis dense hirsutulis pedunculis 8–23 mm. longis, pedicellis 6–14 mm. longis, capsulis 25–32 mm. diametro glabris ¾-lobatis, lobis rotatis, endocarpio glabro.

Typus, Hawaii, Bird Park, Hawaii National Park, open woods, 4,000 ft. alt., Dec. 22, 1931, *H. St. John, R. S. Bean, & E. Y. Hosaka* 11,257, (Ho.).

P. radiata St. John, sp. nov.

Frutex 3 m. alta glabra, foliis oppositis, petiolis 3–9 mm. longis, laminis late ovalibus ad basim subcordatis coriaceis reticulatis 3–7.2 cm. longis, axillis unifloriferis, pedicellis 3–5 mm. longis, capsulis 30–32 mm. diametro glabris ⅘-lobatis, endocarpiis glabris.

Typus, Hawaii, Kapua, Nov. 16, 1926, *L. H. MacDaniels* 273, (Ho.).

P. reflexa St. John, sp. nov.

Ramulis hirsutis, foliis oppositis, petiolis hirsutulis 8–17 mm. longis, laminis 7–13 cm. longis ellipticis subcoriaceis infra sparse hirsutulis deinde glabratis, pedunculis 1-floriferis cum pedicellis 25–30 mm. longis glabratis, capsulis 28–33 mm. diametro glabris ¾-lobatis lobis reflexis.

Typus, Molokai, Wailau Pali, *J. F. Rock* 7,046, (Ho.).

P. Rockii St. John, sp. nov.

Frutex vel arbor, novellis adpressi-puberulis et squamosis, ramis glabratis, foliis oppositis, petiolis puberulis, laminis 3–18 cm. longis ellipticis coriaceis glabris, cymis 8–13-floriferis, pedicellis 3–15 mm. longis, capsulis 18–23 mm. diametro glabris $\frac{1}{2}$-lobatis lobis rotatis, endocarpio glabro.

Typus, Oahu, ridge between Palolo and Waialae, March 23, 1910, *C. N. Forbes* 1,490, (Ho.).

P. Rockii St. John var. **pauciflora** St. John, var. nov.

A planta typica laminis ovalibus, cymis 3–7-floriferis differt.

Typus, Oahu, Kaukonahua gulch, May 15, 1909, *J. F. Rock* 3,046, (Ho.).

P. semiternata St. John, sp. nov.

Arbor, ramulis glabris, foliis ternatis vel oppositis glabris, petiolis 2–18 mm. longis, laminis ellipticis coriaceis subacutis ad basim auriculatis 4–9.5 cm. longis, cymis 1-floriferis cum pedicellis 15–35 mm. longis filiformibus glabris, floribus glabris, capsulis 20 mm. diametro glabris $\frac{2}{3}$-lobatis.

Typus, Oahu, South Opaeula Gulch, Paalaa, 1,700 ft., Nov. 9, 1930, *H. St. John* 10, 638, (Ho.).

P. stellata St. John, sp. nov.

Frutex vel arbor, novellis adpressi-puberulis, ramulis subglabratis, ramis glabris, foliis oppositis, petiolis 10–28 mm. longis glabratis, laminis 5.5–11 cm. longis ovalibus coriaceis glabris, cymis 3–5-floriferis minute adpressi-puberulis, pedunculis 5–12 mm. longis, pedicellis 5–8 mm. longis, capsulis 21–25 mm. diametro subglabris $\frac{2}{3}$-lobatis, lobis rotatis, endocarpio glabro.

Typus, Maui, Makawao, dense lower woods with *Ochrosia sandwicensis*, Oct. 18, 1910, *J. F. Rock* 8,597, (Ho.).

P. Storeyana St. John & Hume, sp. nov.

Foliis oppositis, laminis 9–14 cm. longis subcoriaceis ellipticis costa hirsutula, pedicellis 3 mm. longis, capsulis immaturis 12 mm. diametro $\frac{3}{4}$-lobatis.

Typus, Oahu, Mt. Kaala, Makaleha, or Waialua, Dec. 1870, [J. Lydgate], Herb. Hillebrand, (B.).

CUBICARPAE

P. Brighami St. John, sp. nov.

Ramulis puberulis, foliis oppositis, laminis 3.5–10 cm. longis glabris ovalibus apicibus emarginatis, capsulis 10–14 mm. diametro dense puberulis.

Typus, Maui, Makawao, *H. Mann & W. T. Brigham* 377, (Ho.).

P. elongata (Hbd.) St. John, comb. nov.

P. elliptica (Gray) Hbd. δ var. *elongata* Hillebrand, Fl. Haw. Ids. 69–70, 1888.

P. Forbesii St. John & Hume, sp. nov.

Ramis glabris, foliis oppositis 7.5–9.5 cm. longis ovatis vel obovatis supra glabris, petiolis glabris, capsulis 20–25 mm. diametro glabris.

Typus, Kauai, Waimea drainage, *C. N. Forbes* 869.K, (Ho.).

P. Gaudichaudii St. John, sp. nov.

Foliis oppositis, petiolis hirsutulis, laminis 25–51 mm. longis ovalibus subcoriaceis infra costa hirsutula, capsulis 16–22 mm. diametro cinereo-pubercentibus.

Typus, Iles Sandwich, *Gaudichaud* (P.).

P. hawaiensis Wawra var. **pilosa** St. John, var. nov.

Ramulis petiolisque puberulis, laminis 5–8 cm. longis oblanceolatis vel lanceolatis cuneatis subcoriaceis subtus pilosis.

Typus, Lanai, July 1870, *W. Hillebrand,* (B.).

P. hawaiensis Wawra var. **racemiflora** (Rock) St. John, comb. nov

P. cinerea (Gray) Hbd. var. *racemiflora* Rock, Ind. Trees Haw. Ids. 241, 1913.

P. mucronulata St. John, sp. nov.

Ramulis et novellis pilosulis, petiolis pilosulis, laminis 6–11.5 cm. longis coriaceis infra pilosulis, pedunculis pedicellisque pilosulis, capsulis 24–28 mm. diametro glabris mucronulatis.

Typus, Maui, Pakiloi, south slope of Haleakala, March 23, 1920, *C. N. Forbes* 2,078.M, (Ho.).

P. niuensis St. John, sp. nov.

Arbor, ramis glabratis, foliis oppositis, petiolis glabratis, laminis coriaceis ellipticis glabris 6–12 cm. longis 22–48 mm. latis, inflorescentii 7–9-florifera, capsulis elobatis 21–25 mm. diametro glabris.

Typus, Oahu, Niu, Oct. 13, 1940, *H. St. John* 20, 111, (Ho.).

P. obovata St. John, sp. nov.

Ramulis glabratis, foliis oppositis, laminis 9.5–10 cm. longis anguste obovatis chartaceis obtusis subcuneatis glabris, cymis circa 25-floriferis puberulis, capsulis 20–26 mm. diametro subglabris.

Typus, Maui or Lanai ?, *J. Lydgate* 109, (B.).

P. ovata St. John & Hume, sp. nov.

Ramis glabris, foliis oppositis, laminis 6–13 cm. longis ovatis acuminatis, fructibus 24 mm. diametro glabris.

Typus, Kauai, Kaholuamanu, March 3, 1909, *J. F. Rock* 1,979, (Ho.).

P. ovalis St. John, sp. nov.

Arbor 5 m. alta, novellis puberulis squamosisque glabratis, foliis oppositis, petiolis glabris validis, laminis 8–16 cm. longis late ovalibus coriaceis glabris, cymis 3–7-floriferis glabris, pedunculis 3–12 mm. longis, pedicellis 10–13 mm. longis, capsulis 12–14 mm. diametro subglobosis elobatis glabris, endocarpio glabro.

Typus, Maui, Mountains above Hana, July 5, 1920, *C. N. Forbes* 2,670. M, (Ho.).

P. paniculata St. John, sp. nov.

Arbor 15 m. alta, novellis minute squamosis et puberulis, foliis oppositis, petiolis 3–6 cm. longis glabratis, laminis 9.5–20 cm. longis ellipticis subcoriaceis marginibus revolutis infra costa minute puberula, paniculis 13–20 cm. longis multi-floriferis, pedicellis 2–5 mm. longis, sepalis petalisque glabris, capsulis immaturis 8–9 mm. diametro elobatis tetragonis glabris, endocarpio glabro.

Typus, Kauai, upper Lihue ditch trail, Feb. 21, 1927, *L. H. MacDaniels* 845, (Ho.).

P. quadrangularis St. John & Hume, sp. nov.

Ramulis puberulis, foliis oppositis, laminis 7–13.5 cm. longis ovalibus subcoriaceis supra glabris infra sparse pilosis pallidisque, capsulis elobatis 19–25 mm. diametro 12–14 mm. altis, axilla 8–9 mm. alta, exocarpiis sparse puberulis glabratis, endocarpio glabro.

Typus, Kauai, vicinity of Wahiawa Swamp, Aug. 1909, *C. N. Forbes* 273.K, (Ho.).

P. waimeaensis St. John, sp. nov.

P. sapotaefolia Mann β var. Hbd., Fl. Haw. Ids. 63, 1883.

Ramulis puberulis, foliis oppositis, laminis 12–19 cm. longis anguste elliptici-oblongis coriaceis subemarginatis cuneatis infra pilosis, capsulis 26–28 mm. diametro quadrangularibus elobatis.

Typus, Kauai, Mts. of Waimea, *Knudsen* 38, (B.).

P. Wawraeana Rock var. **pubens** St. John, var. nov.

A planta typica capsulis puberulis, endocarpio ad suturam plusminusve pilosulo differt.

Typus, Oahu, Kaaawa, el. 575 m., April 12, 1931, *E. P. Hume* 157, (Ho.).

P. Wawraeana Rock var. **tenuifolia** (Hbd. ex Rock) St. John & Hume, comb. nov.

P. sandwicensis (Gaud.) Gray var. *tenuifolia* Hbd. ex Rock, Bot. Gaz. **65**: 265–266, 1918.

APOCARPAE

P. adscendens St. John & Hume, sp. nov.

Ramis cinereis, foliis glabris vel glabratis, laminis ovato-oblongis 4.5–7 cm. longis subcordatis, coccis 7 mm. longis glabris.

Typus, Maui, Auwalu, Haleakala, March 24, 1920, *C. N. Forbes* 2,100. M, (Ho.).

P. cinereops St. John, sp. nov.

Arbor, ramulis cinereis, foliis oppositis, petiolis cinereis, laminis ellipticis subcoriaceis 4–9 cm. longis infra valde velutinis, floribus paucis, folliculis 7–10 mm. longis dense pilosis, endocarpio dense villoso.

Typus, Oahu, Mt. Kaala, 1,600 ft., Aug. 14, 1927, *L. H. MacDaniels* 927, (Ho.).

P. elliptica (Gray) Hbd. var. **coccinea** St. John & Hume, var. nov.

Foliis cuneatis, sepalis pilosis persistentibus, capsulis pilosis coccineis.

Typus, Oahu, Makaha Valley, *H. St. John* 11,605, (Ho.).

P. elliptica (Gray) Hbd. var. **mauiensis** St. John, nom. nov.

P. elliptica (Gray) Hbd. β var. Hbd., Fl. Haw. Ids. 69, 1888.

P. haupuensis St. John, sp. nov.

Arbor 8 m. alta, novellis adpressi-puberulis, petiolis 2–5 cm. longis adpressi-puberulis vel glabratis, laminis 4.5–9.5 cm. longis chartaceis glabris ovalibus vel ovatis ad basim rotundatis vel subemarginatis ad apicem rotundatis vel subacutis, cymis 7-floriferis adpressi-puberulis, pedunculis 2–7 mm. longis, pedicellis 1–2 mm. longis, sepalis et petalis adpressi-puberulis, coccis distinctis rotatis glabris 9–11 mm. longis, 6 mm. altis subellipsoideis acutis compressis, endocarpio glabro.

Typus, Kauai, Haupu, Feb. 16, 1927, *L. H. MacDaniels* 746, (Ho.).

P. Saint-Johnii Hume, sp. nov.

Folliis oppositis ternatisve ovato-ellipticis 6–16 cm. longis, cymis 3–7-floriferis, pedicellis 2–5 mm. longis pilosulis, fructibus 12–16 mm. diametro, folliculis glabris aurantiacis.

Typus, Oahu, Mauna Kapu, *E. Christophersen, G. P. Wilder, & E. P. Hume* 1,591, (Ho.).

P. sulfurea (Rock) St. John & Hume, comb. nov.

P. cinerea (Gray) Hbd. var. *sulfurea* Rock, Bot. Gaz. **65**: 265, 1918.

P. tomentosa St. John & Hume, sp. nov.

Foliis oppositis, laminis 7.5–13 cm. longis late ellipticis infra tomentosis, cymis 3–5-floriferis, fructibus 18–21 mm. diametro, folliculis glabris.

Typus, Maui, Auhi, Ulupalakua, *G. C. Munro* 391, (Ho.).